

Institute *of* Physics

# Newsletter

*of*

The Computational Physics Group



Qubits in a  
Quantum Computer

Spring 2003

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Our web page can be found here: <http://www.iop.org/IOP/Groups/CP/>

Comments about the newsletter should be sent to Andrew Horsfield

Picture of the qubits courtesy of Vincent Conrad, University of Melbourne, Australia. See <http://www.ph.unimelb.edu.au/src/whatisaqc.htm>

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## Chairman's Remarks - CCP200x

*Peter Borchers (chairman)*

As many of you will be aware, the IoP is affiliated to the European Physical Society (EPS), which means that all IoP members are members of EPS. (Until a few years ago this was not the case, and one had to join EPS as an Individual Ordinary Member.)

EPS has a Computational Physics Group, of which I have the honour to be chairman. Our two principal activities are organising a summer school, usually held in the Czech Republic and in organising an international conference, known as CCP200x (Conference on Computational Physics). The CCP series of conferences are held, in a three yearly cycle, in Europe, North America, and the rest of the World.

CCP2003 is being held in China from July 20 to 25 (see <http://iccp6-ccp2003.iapcm.ac.cn>).

CCP2004 will be in Genoa, Italy, from 1 to 4 September 2004, under the auspices and support of IUPAP, EPS, APS and the Italian Institute for Condensed Matter Physics (INFM). This promises to be another successful conference, following on from previous conferences organised by the EPS Computational Physics Group, the most recent being those in Krakow (1996), Granada (1998) and Aachen (see <http://www.fz-juelich.de/ccp2001>).

Computational Physics in the UK is in a very healthy state, but this has not been reflected in the attendance at some CCP conferences. Please enter CCP2004 in your diaries now, and start preparing your abstracts. (Note to our many overseas members: this exhortation applies to you too!)

I believe that not many of our members working in industry come to CCP conferences: I should like to see more industrial physicists at all our meetings. If you are working in industry and do not attend our meetings, please can you let us know how we should organise our meetings to encourage you to come.

The provisional outline programme of CCP2004 is:

*Unravelling the Physical World by Computer Simulation*

1. Nanostructures and Material Science.
2. Biostructures and Soft Matter (Polymers, Membranes, Proteins, etc.).

3. Computational Statistical Physics, Turbulence, Plasmas and Reactive Flows.
4. New Methods in Computer Simulation.
5. Lattice Gauge Theory and Elementary Particle Physics.
6. Computational aspects of Astrophysics.
7. Quantum Simulations.
8. Frontiers in Large Scale Computing.

The Conference Chairman is Professor Giovanni Ciccotti from Rome.

## A fun talk on teleportation

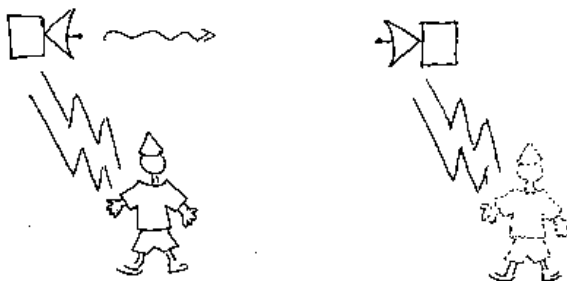
*Prof. Samuel Braunstein*

To start let's ask just what we might mean by the term "teleportation." After all, if someone comes up to you saying "look I've finally done it! I've discovered how to teleport ..." we'd like to be able to decide whether we were even speaking the same language. Fine, so I've seen Star Trek so I figure I can take a stab at defining it: *Teleportation is some kind of instantaneous "disembodied" transport.*

Now wait a second, I can't buy that! Einstein's theory of relativity - and many decades of experimental evidence back him to the hilt - say that the fastest speed is the speed of light. If we take this as part of normative science then we are going to have to change our definition immediately to: Teleportation is some kind of "disembodied" transport. (At least for the moment.) Well that's a little better, but I have been rather vague by what I mean by disembodied. Perhaps I should let the figure below be our best guide to what that might mean:

I guess if I think about this definition for a little while I start realizing that we already have lots of examples of teleportation around us every day:

- telephone: transports sound waves as electricity.
- fax: transports an image.



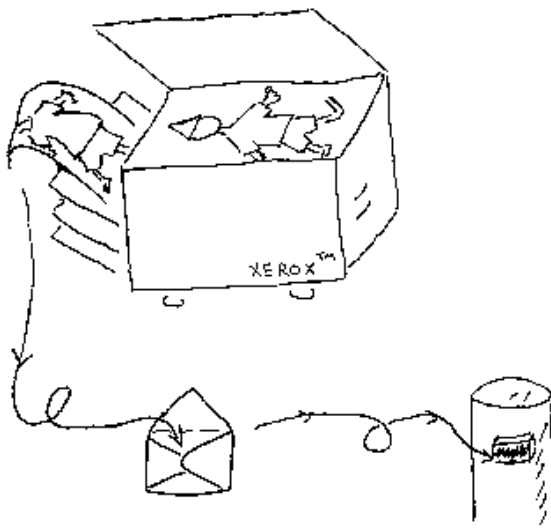
- World Wide Web: ...

Well, do these count as teleportation? They are really copying processes. They leave the sound, image, what-have-you behind and send the copy shooting across space in some disembodied way. Hmmmm, should we buy this? They don't leave a copy behind in our favorite TV program. Well, maybe that's just what they do. They have some machine which measures the positions and velocities and types of atoms throughout the entire person and then send that information (say by radio waves) to the place where the body is reconstructed by another machine. Well, on TV they also learned how to recreate the person from the information apparently without a machine to receive it. (One thing at a time, please!)

What about the original? Well, maybe the machine which measures all those atoms has to slice the person apart to do that. I guess that would be like a photocopy machine with a flash lamp which was set too hot (vaporizing the original). This wouldn't be an absolute requirement. As soon as someone worked out how to build a more gentle copying process they could leave the original behind. Would they want to? Would the soul be copied? Would the copy still have to pay taxes if the original were still around? I guess I can't answer every pressing question.

Of course if we could ever learn how to do this we might find new fields of research like "experimental religion." Who knows?

Just how much information are we talking about anyway? Well the visible human project by the American National Institute of Health requires about 10 Gigabytes (that's about  $10^{11} = 100,000,000,000$  "bits," or yes/no answers,



this is about ten CD ROMs) to give the full three dimensional details of a human down to one millimeter resolution in each direction. If we forget about recognizing atoms and measuring their velocities and just scale that to a resolution of one-atomic length in each direction that's about  $10^{32}$  bits (a one followed by thirty two zeros). This is so much information that even with the best optical fibers conceivable it would take over one hundred million centuries to transmit all that information! It would be easier to walk! If we packed all that information into CD ROMs it would fit into a cube almost 1000 kilometers on a side! Enough said?

Hey, but you're all clamouring out there "what about the uncertainty principle, can you really measure things that accurately?" Well quantum theory tells us that the precision with which we can measure position and velocity of any particle are limited by a very simple formula:

$$\frac{\Delta x}{a_0} \times \frac{\Delta v}{c} > 10^{-6} \times \frac{M_H}{M} \quad (1)$$

where  $\Delta x$  is the uncertainty in position,  $a_0$  is the size of a hydrogen atom,

$\Delta v$  is the uncertainty in velocity,  $c$  is the speed of light,  $M_H$  is the mass of a hydrogen atom and  $M$  is the mass of the particle.

If we want to measure each atom to within a typical atomic size this means that the velocities will be uncertain by about 300 meters per second (if the particle weighs as much as a Hydrogen atom say). This sounds fast, but it's not so bad. The ordinary jiggling of our atoms due to us being at room temperature is bigger than this by a factor of three or more. In other words, the uncertainty principle doesn't appear to be too restrictive in terms of how well we can measure those atoms.

Of course, that's not all. What about the "quantum state" of those atoms? Does it matter what energy levels they are all in? Do the chemical reactions need to have this information to work once we reassemble the atoms to make a person? Well, my best guess is no! As is the best guess of several other scientists I've asked too. But that's hardly a definitive answer. I guess what tends to convince me that the detailed quantum state is not important to get right when you want to copy a person and make a new one from the partial information is that people routinely go to hospitals for NMR (nuclear magnetic resonance) and ESR (electron spin resonance) scans to see inside them. These procedures mix up the quantum states of at least some large number of atoms and nuclei of the people being scanned, yet it doesn't seem to disturb their appetites (that makes them still human in my book). Thus here again the quantum nature of our atoms and molecules doesn't appear to rule out the copying method for teleportation.

The sheer amount of information involved though is still mind boggling! Perhaps we should start with something smaller ...

*This talk is taken from*

*<http://www.informatics.bangor.ac.uk/~schmuel/tport.html>.*

*To learn about quantum computing see*

*<http://www.informatics.bangor.ac.uk/~schmuel/comp/comp.html>.*

## Upcoming Computational Physics Group Events

### The 2<sup>nd</sup> Annual Computational Physics Thesis Prize

Note: the deadline has been extended

The Committee of the Institute of Physics Computational Group has endowed two annual prizes. £500 will be awarded to the author of the PhD thesis that contributes most strongly to the advancement of computational physics. The Committee will select the recipients and its remit will be very broad, in order to capture a broad spectrum of modelling activity.

- The deadline for applications is December 31<sup>st</sup>, 2003. Applications received in 2002 or 2003 will be considered.
- The submission format is a 4 page (A4) abstract.
- The submission address is:  
PROFESSOR A D BOARDMAN  
HON. SEC, IOP COMPUTATIONAL PHYSICS GROUP  
JOULE PHYSICS LABORATORY  
SCHOOL OF SCIENCES  
UNIVERSITY OF SALFORD,  
SALFORD, M5 4WT

*Applicants must have carried out their thesis work at a University in the United Kingdom or the Republic of Ireland.*

### Computational Physics Symposium

This symposium is part of the CMMP meeting of the IoP in Belfast. It will take place on the afternoon of Wednesday, April 9<sup>th</sup>, 2003. Embedding of quantum calculations in classical calculations will be a theme.

Web page: <http://www.iop.org/IOP/Confs/>

### A Gentle Introduction to Quantum Information

On Friday, September 12, 2003, we will hold a meeting at the Institute of Physics, 76 Portland Place, London, that will be an introduction to the theory

of quantum information. This meeting will be aimed at those who are interested in the field but are not practitioners. A very exciting range of speakers will cover a variety of topics, including Simon Singh who will talk about cryptography.

Web page: <http://groups.iop.org/CP/>

## **Other Upcoming Meetings**

### **Large-scale scientific computations**

The fourth international conference on large-scale scientific computations will be held in Sozopol, Bulgaria from June 4<sup>th</sup> to 8<sup>th</sup>, 2003.

Web page: <http://parallel.bas.bg/scicom03>

### **Scientific computing and differential equations**

A conference on scientific computing and differential equations will be held in Trondheim, Norway from June 30<sup>th</sup> to July 4<sup>th</sup>, 2003.

Web page: <http://www.math.ntnu.no/scicade>

### **Computational techniques and applications**

The conference on computational techniques and applications will be held within the format of the international Congress of industrial and applied mathematics in Sydney, Australia from July 7<sup>th</sup> to 9<sup>th</sup>, 2003.

Web page: <http://www.math.ntnu.no/scicade>

### **UKHEC events**

UK High-End Computing has a number of upcoming events of interest to physicists. Check the web page for details.

Web page: <http://www.ukhec.ac.uk/events/>