IQC Institute for Quantum Computing www.iqc.ca

University of Waterloo

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THE INSTITUTE FOR QUANTUM COMPUTING

NewBit

BREAKING GROUND, MAKING HISTORY

QUANTUM-NANO CONSTRUCTION UNDERWAY

Construction is now underway on the *Mike and Ophelia Lazaridis Quantum-Nano Centre (QNC)* – the future home of IQC and the Waterloo Institute for Nanotechnology.

The official ceremony, held June 9th, had distuguished guests on hand to break ground including Ontario Premier Dalton McGuinty; Co-CEO of Research in Motion Mike Lazaridis and wife Ophelia; UW President David Johnston; Chair of the UW Board of Governors Bob Harding; Minister of Training, Colleges & Universities John Milloy; and MPP for Kitchener-Conestoga Leeanna Pendergast.

Following the ground-breaking, guests were treated to tours of IQC and Nanotechnology laboratories to see research at the two institutes up-close.

The five-story, state-of-the-art Quantum-Nano Centre is set to include an advanced metrology suite, teaching and research laboratories, Class-100 and Class-1000 clean rooms and a large atrium.

When the dust has settled in late 2010 or early 2011, over $160 million will be have been invested in the most complex scientific building at the University of Waterloo.

The Government of Ontario announced it will provide $50 million for construction, with another $22 million coming from a Lazaridis family donation. Other funding sources include the university, private donations, and the federal government.

The NewBit will continue to report on the QNC progress throughout the construction.

FACULTY EXPANSION

BEN REICHARDT MAKES 17

IQC is pleased to welcome its newest faculty member Ben Reichardt who comes to us from a postdoctoral position at the California Institute of Technology.

Ben's research lies in the important area of fault tolerant quantum computing.

He completed his PhD in 2006 at the University of California, Berkeley, under Umesh Vazirani's supervision.

In his thesis, Dr. Reichardt gave the first proof that fault tolerance schemes based on noise detection could in fact function in the presence of noise, and he established a lower bound threshold of 0.1% noise per gate.

Ben is currently working on quantum algorithms for evaluating formula and on entanglement renormalization for string-net models.

CALCULATED SUCCESS

Visitors

IQC IS HONOURED TO HAVE HOSTED THESE DISTINGUISHED GUESTS OVER THE SPRING & SUMMER OF 2008:

- Daria Ahrensmeier - Trent University
- V. Arvind - Institute of Mathematical Sciences, CIT Campus Taramani
- Stephen Bartlett – University of Sydney
- Claudia Brillmann - Ministry of Economics of the German Federal State of Rheinland-Pfalz
- Cecilia Cormick - University of Buenos Aires
- Marcos Curty – University of Toronto
- Sagarmoy Dutta - Indian Institute of Technology Kanpur
- Torsten Franz - Technical University of Braunschweig
- Markus Grassl - Institute for Quantum Optics and Quantum Information, Austria
- Jozef Gruska - Masaryk University
- Brendon Higgins - Griffith University
- Tsuyoshi Ito - McGill University
- Elham Kashefi - School of Informatics, University of Edinburgh
- Hartmut Klauck - Frankfurt University
- Emanuel H. Knill - National Institute of Standards and Technology
- Hirotada Kobayashi - National Institute for Informatics, Japan
- Jan Ivar Korsbakken – University of California, Berkeley
- Anthony J. Leggett - University of Illinois at Urbana-Champaign
- Anthony Leverrier - Institut d'Optique, France
- Yi-Kai Liu - Caltech
- Shiang Yong Looi - Carnegie Mellon University

DUALLY RECOGNIZED

IQC faculty member Ashwin Nayak has been awarded both an NSERC Discovery Accelerator Supplement (DAS) and a grant from Human Resources Social Development Canada (HRSDC) this year.

The NSERC DAS Program provides substantial and timely additional resources to accelerate progress and maximize the impact of outstanding research programs.

The grants are awarded to researchers who show strong potential to become international leaders in their respective area of research.

Each supplement will provide recipients with the necessary resources to compete with the best in the world.

Nayak's HRSDC proposal titled, "Collaborative Student Training in Quantum Information Processing," was also approved.

The project will formally initiate student and faculty exchange across several Canadian and Eurpean institutions which have a strong research effort in quantum information processing (QIP).

Ashwin's project aims to consolidate and expand existing collaborations to provide a larger pool of talented student access to expertise available beyond their home institutions. It will also provide a platform for developing a standardized suite of courses dedicated to the rapidly developing field of QIP.

NEW CIFAR INDUCTEES

The Canadian Institute for Advanced Research announced their new Fellows, Scholars, and Associates to the Quantum Information Processing program. Some familiar names were among the inductees:

New Fellows:
Daniel Gottesman *(IQC Affiliate)*
John Watrous *(IQC Faculty)*

New Scholars:
Joseph Emerson
(IQC Faculty)

New Associates:
Scott Aaronson
(Former IQC Post-Doc)

Canadian Institute for Advanced Research

More information about CIFAR can be found online at www.cifar.ca

SCHOLARSHIPS & AWARDS

Congratulations to the following students who received scholarships and awards over this term:

Devon Biggerstaff
GWPI Poster Session Winner - UW & IQC M.Sc. Candidate at the Graduate Level
Mike & Ophelia Lazaridis Fellowship
Fall, 2008

Omar Gamel
Bell Family Research Fund
Fall, 2008

Gus Gutoski
Bell Family Research Fund
David R. Cheritan Scholarship
Fall, 2008

Robin Kothari
Mike & Ophelia Lazaridis Fellowship
Fall, 2008

Chandrasekhar Madaiah
Mike & Ophelia Lazaridis Fellowship
Fall, 2008

Brendan Osberg
OGS Award
Fall, 2008

Farzad Qassemi-Mallomeh
Mike & Ophelia Lazaridis Scholarship
Summer, 2008

Jamie Sikora
OGS Award
Fall, 2008

Marcus Silva
Bell Family Fund
Summer, 2008

Cozmin Ududec
OGS Award
Fall, 2008

Sarvagya Upadhyay
Bell Family Fund Award
Summer, 2008

REWARDING RESULTS

EARLY RESEARCHER AWARD

IQC professor Joseph Emerson has garnered an Early Researcher Award from the Ministry of Research and Innovation for his work on assessing and improving quantum information processing devices.

Emerson is developing methods for assessing and improving the performance of quantum information devices in the presence of noise, a key step toward making large-scale quantum information processors viable.

His work on randomized methods of noise estimation has shown great promise as a practical tool that experimentalists can use to diagnose and potentially correct sources of noise affecting the performance of quantum computers.

With his Early Researcher Award, Emerson will continue to develop the theory of symmetrized noise estimation. He is particularly interested in understanding how to obtain more information about memory effects in noise, the spatial distribution of error locations, and the presence and location of noiseless subsystems.

Ultimately, these methods will help physicists and engineers develop robust quantum computing devices.

NSERC SUPPLEMENT FOR IQC AFFILIATE

David Kribs, Associate Professor in Mathematics and Sciences at the University of Guelph and an affiliate member to IQC has been awarded a 2008-09 Discovery Accelerator Supplement.

Professor Kribs' research seeks new techniques and develops established technologies for the correction of errors in quantum information processors.

Mitigating the effects of errors which disrupt attempts to control and maintain features of quantum systems as they evolve is of central importance to the QIP.

While substantial progress has been made on this front, the basic problem of "quantum error correction" remains one of the primary impediments to large-scale quantum computing.

NSERC CRSNG

The award selection committee commented, "the supplement would allow Dr. Kribs to keep up with his first rate cutting edge research in quantum computing...augmenting Dr. Kribs' research support at this high-need time in his career would result in a significant pay-off for Canada."

SIR ANTHONY LEGGETT LECTURE SERIES

IQC was thrilled to once again host our Associate Member and Scientific Advisor, Sir Anthony J. Leggett of the University of Illinois at Urbana-Champaign this summer.

Professor Leggett braved the stage once again to educate the enthusiastic minds of Waterloo with his Lecture Series entitled "Prospects for Topological Quantum Computing".

For four weeks, IQC and UW students and faculty were invited to hear the 2003 Nobel Prize winner in Physics teach what he knows best.

Dr. Leggett introduced the general idea of topological protection and its possible application to quantum computing.

He then surveyed various physical systems which have been proposed in the literature for implementation of these ideas (quantum Hall effect, Sr_2RuO_4, optical lattices...).

With emphasis on the physical aspects of the problem, Sir Leggett explored the extent to which theoretical ideas about these systems are currently confirmed by experiment.

Finally, he dove into the kinds of difficulties which are likely to arise in any serious implementation attempt were explored.

The 2008 Sir Anthony Leggett Lecture Series slides are available online at www.iqc.ca

Visitors

- Francesco De Martini - Universita de Roma
- Alexandre Martins de Souza - Brazilian Center for Research in Physics
- William Matthews – University of Bristol
- Denise Maurice – École Normale Supérieure
- Evan Meyer-Scott - University of Alberta
- Jagadeesh Moodera - Massachusetts Institute of Technology
- Kae Nemoto - National Institute for Informatics, Japan
- Geoff Pryde - Griffith University
- Volkher Scholz - Technical University of Braunschweig
- Rolando Somma - Perimeter Institute for Theoretical Physics
- René Stock - University of Toronto
- Till J. Weinhold - Griffith University
- Wim Van Dam - University of California, Santa Barbara
- Dervis Can Vural - University of Illinois at Urbana-Champaign
- Man-Hong Yung - University of Illinois at Urbana-Champaign
- Guojun Zhu - University of Illinois at Urbana-Champaign
- Karol Zyckowski - Polish Academy of Sciences, Center for Theoretical Physics

To find out more about our visitors, please visit: www.iqc.ca/people and click on "Visitors"

REACHING OUT

Speakers

- May 5 – Anne Broadbent
  "Universal Blind Quantum Computation"
- MAY 12 – V. Arvind
  "On noncommutative polynomial identity testing"
- JUNE 2 – Stephen Bartlett
  "Transitions in universality: investigating measurement-based quantum computation using percolation theory and valence-bond solids"
- JUNE 16 – Yi-Kai Liu
  "Towards quantum algorithms using the curvelet transform"
- JUNE 19 – Anton Burkov
  "Nonequilibrium dynamics in cold atom condensates"
- JUNE 23 – René Stock
  "Quantum computing with atoms – entangling operations and rapid single-qubit manipulation and measurement"
- JULY 4 – Markus Grassl
  "Coset Stabilized Quantum Codes from Goethals and Preparata Codes"
- JULY 7 – Rolando Somma
  "Quantum Algorithms for Adiabatic Evolutions and Applications"
- JULY 21 – Daniel Gottesman
  "Entanglement vs. gap for one-dimensional spin systems"
- JULY 28 – Wim Van Dam
  "Algebraic Quantum Circuits"
- AUGUST 5 – Jagadeesh Moodera
  "Spin polarized tunneling phenomenon – Before and Now"
- AUGUST 11 – Michele Mosca
  "Cryptography in a Quantum World"
- AUGUST 14 – Cecilia Cormick
  "Decoherence by spin-chain environments"
- AUGUST 15 – Andris Ambainis
  "Quantum and classical query complexities are polynomially related for all symmetric functions"
- AUGUST 18 – Jozef Gruska
  "From Computer Science to Informatics – New Perception of the Discipline"
- AUGUST 25 - Karol Zyczkowski
  "Random quantum operations"
- AUGUST 27 – Francesco De Martini
  "Entanglement, nonlocality, coherence and decoherence of a macroscopic quantum superposition"

To view a full listing of upcoming speakers

please visit our website at:

www.iqc.ca/activities/seminars.php

BIG TURNOUT FOR OPEN HOUSE, PUBLIC LECTURE

IQC opened its doors to the public on August 11th for our 2nd Annual Open House. The showcase of IQCs research labs gave over 150 guests the opportunity to explore and learn what goes on behind closed doors.

The tours were followed by a public lecture to a capacity crowd on Quantum Cryptography. The lecture was presented by Deputy Director Michele Mosca, who detailed the effect of quantum information processing on information security as we know it.

The event was a huge success with visitors of all ages, from across the province and as far away as our nation's capital.

EAGER INTEREST

The *Quantum Cryptography School for Young Students (QCSYS)* was an exciting program offered by IQC and QuantumWorks to Canadian students in Grade 11, held August 11-15th.

Students were given a first-hand look into quantum cryptography–one of the most exciting topics in modern science–and had the opportunity to meet some of the most renowned researchers the field has to offer.

Students also received a tour of quantum computing and quantum cryptography experiments.

"The summer school [gave] a clearer picture of the field of quantum cryptography and how different fields of studies can come together for one purpose", commented one of the participants.

Organizers hope to repeat the successful school next year.

SCHOOL'S IN FOR GRAD STUDENTS, INDUSTRY

IQC was host to the *Information Security in a Quantum World* summer school this summer from August 7th-11th.

The school was aimed at graduate students and industry researchers who wished to deepen their understanding of the theory and experimental realizations of quantum cryptography.

Experts from around the globe were invited to speak, including Christian Kurtsiefer and Valerio Scarani from the National University of Singapore, Hoi-Kwong Lo from the University of Toronto, and Renato Renner of the Swiss Federal Institute of Technology along with local professors from Waterloo.

Key industry speakers also attended from MagiQ, Telcordia, Ontario Centres of Excellence, Princeton Lightwave and NEC.

Over 60 people participated this summer and organizers hope to emulate the experience again next year with an international appeal.

GETTING AN EARLY START

St. Nicholas Catholic School students sat in awe as IQC Professor Kevin Resch explored everything one would want to know about a physics professor and researcher for Career Day.

Equipped with a laser show, Kevin gave students a chance to play with the beam and to see how light travels through different objects.

By the end of the presentation, a sea of hands were in the air, eagerly awaiting answers to questions including which courses to pursue in high school, in hopes of someday working at IQC.

We can only hope that someday the students will be playing with lasers of their own.

EXPANDING ROSTER

IQC GAINS FACULTY, POSTDOC, STAFF

Christophe Couteau
Assistant Professor, Physics

Christophe has been with IQC as a Post-Doctoral Fellow for two and a half years.

He recently accepted a Research Assistant Professorship with IQC and the Department of Physics & Astronomy department at UW.

Christophe will be taking over the Photonic Entanglement Lab where he will push the boundary of optical quantum information processing.

Anne Broadbent
Postdoctoral Researcher

Anne recieved a B.Math in Combinatorics and Optimization from UW and completed both an M.Sc. and Ph.D. under the supervision of Gilles Brassard and Alain Tapp at the University of Montreal.

Her research focus is quantum multi-party cryptographic protocols that are information-theoretically secure.

Zoltan Voros
Postdoctoral Researcher

Zoltan received his MSc. in physics at Lorand Eotvos University, Hungary in 2002 with a thesis on coupled cavity semiconductor lasers.

He has worked as a research assistant in the Photonics Laboratory of the Central Research Institute in Budapest, and David Snoke's experimental group in Pittsburgh, where he was since conducting experiments on excitonic Bose-Einstein condensation and exciton dynamics.

Vito Logiudice
Director of Operations, Fab. Facility

IQC is happy to announce the arrival of Vito Logiudice, who joined the team on June 1st.

Vito will be responsible for the management and daily operation of the fabrication/metrology facility.

Vito comes to IQC from McGill University in Montreal, Quebec, where he worked as a Manager of the Micromachining Cleanroom Facility.

DIRECTOR FLIES SOUTH

Above: David Fransen accepting a Peter Etril painting at his farewell party.

IQC's Executive Director, David Fransen has decided to take a position as the Canadian Consul General in Los Angeles, California.

"David has played a critical role in bringing IQC from a nascent institute to a full fledge one that now comprises more than 100 researchers," says IQC Director, Raymond Laflamme. "His help has been critical in putting in place its administrative backbone, increasing collaboration with government agencies and insuring the success of the future IQC building."

Fransen will remember IQC fondly, commenting, "I firmly believe that IQC, UW, and Waterloo are truly going to have a global impact. It is a message that I will be only too happy to spread in California."

IQC thanks David for all that he has done and wishes him the best in this new and exciting challenge that lay ahead.

Departures

We bid members who are leaving us for the short, and the for the longer term, and wish them the best of luck in their future endeavours.

- Kayle Castor
  Research Assistant
- Pierre-Luc Dallaire Demers
  Research Assistant
- Chantal Hutchinson
  Research Assistant
- Denise Maurice
  Long-Term Visitor
- Zachari Medendorp
  Research Assistant
- Brendan Raw
  Research Assistant
- Peter Routledge
  Staff - Computer Support Specialist
- William Sellier
  Research Assistant
- Marcus Silva
  Ph.D. Student
- Miroslava Sotakova
  Long-Term Visitor
- Kyle Thompson
  Research Assistant
- Matthew Volpini
  Research Assistant

MAKING HEADLINES

Future Events

APS WINNER TO GIVE COLLOQUIUM

David Hume, winner of this year's APS award, will give the IQC colloquium on Monday, September 8th from 12:30-1:30 p.m in RAC 2009.

David will present his talk , "Quantum Logic and the Al+ Optical Clock" which deals with techniques of measuring inaccessible ion systems.

All are encouraged to attend.

MEET & GREET BBQ

To welcome all of our new IQC members arriving in the Fall, the 2nd Annual Meet & Greet BBQ will be held

September 12th from 4:00-8:00 p.m. on site. IQC members, families and friends are welcome to attend.

MONDAY TALKS MOVED TO RAC

Starting in September, the Monday's colloquium previously held in the Math & Computer building will now be moved to RAC 2009 for the duration of the Fall term.

For questions, comments or general feedback regarding IQC contact:

iqc@iqc.ca

WILHELM'S REVIEW GRABS ATTENTION

The building blocks of actual physical implementations of quantum computation are becoming more and more mature. As part of a new insight issue of the leading science journal Nature, John Clarke of UC Berkeley and Frank Wilhelm of IQC review the field of superconducting circuits for quantum computing. Excerpts from the article follow.

Superconducting circuits are macroscopic in size but have generic quantum properties such as quantized energy levels, superposition of states, and entanglement, all of which are more commonly associated with atoms.

Superconducting quantum bits (qubits) form the key component of these circuits. Their quantum state is manipulated by using electromagnetic pulses to control the magnetic flux, the electric charge or the phase difference across a Josephson junction (a device with nonlinear inductance and no energy dissipation). As such, superconducting qubits are not only of considerable fundamental interest but also might ultimately form the primitive building blocks of quantum computers.

The full article can be viewed online at: www.nature.com

GOING BEYOND THE LIMITS

IQC Post-Doc Tzu-Chieh Wei, together with University of Illinois at Urbana-Champaign collaborators Julio T. Barreiro and Paul G. Kwiat, published an article titled, "Beating the channel capacity limit for linear photonic superdense coding" in the April issue of Nature Physics.

Superdense coding harnesses the power of quantum mechanical entanglement and allows communication of two classical bits by sending only a quantum bit.

Photons, traveling at the speed of light, are the natural candidate for performing this task. However, due to the limitations of linear-optics, only 1.58 classical bits per photon can be achieved in the ideal case.

To overcome this obstacle, schemes using simultaneous entanglement in multiple degrees of freedom (hyperentanglement) have been proposed.

Barreiro et al. have produced pairs of photons that are hyperentangled in two degrees of freedom and have used them to perform a new superdense coding scheme, breaking the conventional threshold.

The full journal can be viewed at: www.nature.com/naturephysics

LOCAL CELEBRITIES

Two days following the IQC Open House & Public Lecture, IQC Postdoctoral Researcher Rainer Kaltenbaek and his team in the Quantum Optics Lab were featured on the front page of the local section of the Kitchener-Waterloo Record on August 13th.

Diving into details about the current research being done in the lab, the article picks the brains of our researchers to explain how they manipulate nature's behaviour at the atomic and subatomic level.

The full article can be viewed at: http://news.therecord.com

DEFYING GRAPHITY

IQC postdoctoral fellow, Simone Severini's work in collaboration with Perimeter Institute researchers Fotini Markopoulou and Tomasz Konopka was featured in an article titled, "Quantum graphity" in the May issue of New Scientist.

The team set out to show that space-time and gravity emerge from what they call a "pre-geometric" state.

The full article can be viewed at: www.newscientist.com

EXTRA CURRICULAR

RAC WARMING PARTY

IQC celebrated its new home in the UW Research Advancement Centre with a barbeque and open house May 2nd. We proudly showed off our new facilities to IQC and UW members, friends, and family.

Barbeque favourites were served to guests as they got a first glimpse at our new establishment.

With only a single week of occupancy under our belt, the half-unpacked boxes and "organized mess" didn't dampen the occasion.

IQC appreciates the hard work and dedication of everyone that has helped us get where we are today.

MONKEYING AROUND

In June, our youngest IQC members and parents took a walk on the wild side with a trip to the Toronto Zoo. An event that's become an annual tradition, it was the last event organized by Birgit Weihs for the Spousal Network before she departed with husband, IQC faculty member, Gregor Weihs.

The pack got to see the award winning African Savanna and Gorilla Rainforest, the new Great Barrier Reef, and the Snow leopard and Siberian tiger cubs exhibit among all the other exotic attractions.

WEIHS FAREWELL

IQC professor Gregor Weihs and his family said their goodbyes at their farewell party on June 21st. IQC members and friends of the Weihs gathered to celebrate their time spent in Waterloo.

Gregor's wife Birgit, played an important role in the PI/IQC Spousal Network where she helped organize many of their events such as the Spousal Network Open House.

The Weihs family will be greatly missed and we wish them good luck as they move back to their home country, Austria.

JOHN MAYER CONCERT

IQC members and friends travelled to the Molson Ampitheatre on July 7th to attend the John Mayer Concert. A generous gift from Mike Lazaridis, the concert was a great night out in Toronto.

With opening acts, Colbie Caillat and Brett Dennen, everyone in attendance enjoyed the night out in Toronto as John strummed out hits like "Waiting on the World to Change" and "Gravity".

With Research in Motion sponsoring his Summer tour, his stop in Toronto was his only Canadian venue - lucky for us!

We'd like to extend our gratitude to Mike Lazaridis for providing us with such a great night of entertainment.

GETTIN' FIRED UP!

To spice up the everyday lunches and enjoy the weather throughout the Spring and Summer seasons, we grill up everything from hot dogs, to chicken burgers, to shish kabobs every Friday at noon.

IQC members are reminded that the bbq is open to everyone including spouses and family members. In addition, the last Friday of every month the bbq will be held at 5:00p.m.

Above: Jonathan Lavoie, Michele Mosca, Devon Biggerstaff, Nathan Killoran, and Hauke Haseler sit and enjoy the weekly feast.

BBQ Friday's will continue to run into the Fall term as long as the weather persists. Remember to bring your own favourites!

BRICK BREWERY TOUR

On Friday, August 15th, IQC took a tour of Waterloo's Brick Brewery. Members received a brief history lesson on the company and how the founder, Jim Brickman, fine tuned the skills needed to start Ontario's first craft brewer.

With lessons on how to properly taste the beer, who wouldn't have had fun that night?

Athletics

BASEBALL

IQC members were swinging their bats and running the bases this summer at the baseball games organized at Waterloo Park. It was a great opportunity for all of our international members especially, who got their first ever taste of the North American pastime.

BALL HOCKEY

With the melting snow, the winter ice hockey games were converted to ball hockey over the course of the Spring and Summer months. Held in the IQC parking lot at 4:30 every Tuesday, everyone is still invited to come out and enjoy themselves while the sun is still shining.

SOCCER

Sunday afternoons were host to IQC pick-up soccer games at Waterloo Park this spring.

Organized by Christophe Couteau, there was a great turn-out week after week, as one game turned into two or three to accommodate the large amount of players who came out.

These games will continue into the Fall, weather permitting.

Did You Know?

Albert Einstein could not find a job in physics upon graduating from college, and became a technical assistant in the Swiss Patent Office. He worked on theoretical physics in his spare time.

IQC THANKS ITS PARTNERS FOR THEIR CONTINUING SUPPORT OF OUR VISION

MIKE LAZARIDIS

- AND -

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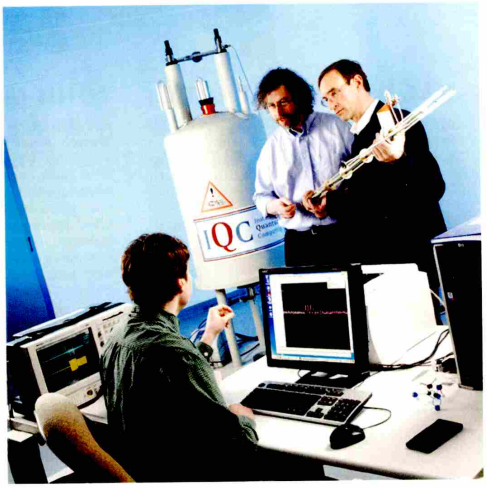

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