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NII SPECIAL

Compute by “Cooling” Quantum System

Betting on the Quantum Computer
—A Unique Approach to Quantum Computing

The Mysterious World of Quantum Mechanics Heralds the Future of Information Processing

The NII Quantum Information Science Theory Group: The Global Standard in Theory

Yoshihisa Yamamoto
Professor, Principles of Informatics Research Division, NII
Professor, Stanford University

NII Interview: Yoshihisa Yamamoto + Aya Furuta

Betting on the Quantum Computer

A Unique Approach to Quantum Computing

Furuta: The theory of the quantum computer was developed in the 1980s. At the time, it did not attract any attention at all, but you began your research immediately.

Yamamoto: I was excited by the idea that there is a connection between information science and physics that at first glance seem far apart from one another. Quantum mechanics involves some mysterious phenomena, such as the idea that monitoring something changes its state and the fact that a correlation between two particles does not disappear no matter how far apart they are from one another. In a quantum computer algorithm, these quantum mysteries are used as basic principles. The act of making the quantum computer a reality is also the act of verifying the core of quantum mechanics, and I find that very intriguing.

I assumed photons as quantum bits(*1) and considered the idea of constructing a basic gate that would cause two bits to interact with one another. To achieve this goal, however, optical crystals with extremely radical properties are needed, and so this was impractical. There were other, more urgent topics, so my interest shifted to them.

Furuta: At the time, you said that quantum computers would never become a reality.

Yamamoto: I never said that officially. That's because such predictions are almost always wrong (laugh). But all of the researchers who knew the reality of the experiments felt something close to that.

Now the situation has changed. Many extremely talented people have participated in the field and are challenging various possibilities. A number of methods have been proposed to achieve quantum computing. But I still have a feeling that none of the methods that are being considered today will pan out. The current approach of creating a quantum gate that operates quantum bits and then combining these to execute a quantum algorithm is simple in mathematic terms, and it's not a mistake. But that doesn't mean it's necessarily the right answer in engineering terms. I'm certain that no matter how hard we work with this approach we'll never achieve a goal.

Furuta: Why not?

Yamamoto: Because it's in direct opposition to nature. Everything in this world is connected to the outside world. However the proposed quantum register that stores the data for a quantum computer must be completely cut off from the outside world or the calculations will be in error. They say that computing will be possible if error correction is done at every step, but there are limits to the degree to which human beings can engineer the natural world. We need to think of a way that is not in conflict with

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Compute by "Cooling" Quantum System

(*1) Quantum bit: the smallest unit of quantum information. May also refer to a photon, electron spin or other material that contains this information.

(*2) Traveling salesman problem: A problem in which the objective is to determine the route by which a traveling salesman can visit multiple cities in the shortest possible distance. One of the "combinational explosion" problems in which a slight increase in the number of destinations causes an explosive increase in the number of calculations required.

(*3) Bose-Einstein condensate (BEC): A phenomenon in which, when a gas composed of many atoms is cooled using a laser, all of the atoms reach the identical lowest energy state and begin to act as a single enormous atom. This phenomenon was predicted by Einstein and was first achieved in 1995.

Aya Furuta

Staff Writer, Science & Technology News Deoartment, Nikkei Inc.

nature and yet brings out the essence of quantum mechanics.

Furuta: What methods are there?

Yamamoto: What we're considering right now is a method of creating a system in which determining the state at which the energy in the physical system is at a minimum (the ground state) will provide the answer to the mathematical problem that you want to solve.

Have you heard of the traveling salesman problem?(*2) In this problem, you determine the shortest route that will allow a salesman to visit multiple cities. If the salesman is going to visit 30 cities, then with existing computers it is impossible to calculate the answer, even if you keep calculating until the end of the universe.

Suppose we transpose this problem to a physical system in which many particles are grouped together. The particles are the cities. For the distances between cities that are near to one other, we diminish the interaction between particles; for the cities that are far from one other, we enhance the interaction between particles. The distance traveled between cities is equivalent to the interaction energy between particles. We build in the interaction between particles such that the distance traveled when all cities are visited becomes the total energy in the system. If we determine the state at which energy is at a minimum, in other words the ground state, that will be the shortest route.

Furuta: How do you determine the ground state?

Yamamoto: You bring the system to the ground state through experimentation. You keep cooling the materials and at absolute zero the system is at ground state. In technical terms, this is the same as creating a Bose-Einstein condensate (or BEC) (*3). In order to solve a mathematical problem, various conditions are imposed on particle energy, and the particles interact with each other as well. The challenge is how quickly we can cool a system that is far more complex than even a BEC.

Fortunately, however, when a sufficient number of photons or other bosons reach the ground state, other bosons also go down to that state. I have high hopes for this power of nature.

Furuta: This is a radical departure from current quantum computers.

Yamamoto: Yes, it is. Current quantum computers use an interferometer to cause many particles to interfere with one another. The interference pattern provides the solution to a mathematical problem. The quantum computer I'm describing is a refrigerator that progressively cools a multi-particle system, and the state at absolute zero provides the answer to the problem. The method is completely different, although I think there are some similarities.

Furuta: How many years do you think it will take you to achieve this computer?

Yamamoto: ...Five years.

Furuta: That's very quick. It's been said that it will take more than 50 years to achieve the quantum computer as it is currently conceived.

Yamamoto: Major inventions are usually achieved within five years of when the concept is developed. If it can't be done in five years, it will probably never become a reality. The next five years will determine success or failure.

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A Word from the Interviewer

A quantum computer lighted the new philosophy that computing is a physical phenomenon,thus a new physical phenomenon can become a new computing process. The quantum computer of Professor Yamamoto employs a unique approach, that of utilizing the BEC, which was only recently developed a dozen or so years ago, to perform computing. Apart from using quantum phenomena to execute calculations, it represents a radical departure from the existing quantum computer in every way, from the phenomena it uses to the algorithms it employs. Undoubtedly computers based on this type of out-of-the-box thinking will continue to appear. I look forward to the day when this pioneering "refrigerator" quantum computer becomes a reality.

Compute by "Cooling" Quantum System

The Mysterious World of Quantum Mechanics Heralds the Future of Information Processing

Though quantum computers are occasionally the subject of articles in newspapers and other media, we have no clear idea as to what they really are or what they will look like. A means of creating such computers, and the form in which they will take, must be left to the future. Nevertheless, we can say that quantum computers will operate based on the principles of quantum mechanics. In this way, computers in operation today are rightly called "classical computers" as they operate on classical principles. A quantum computer in the future will have the potential to integrate the processing power (capacity) of all today's classical computers onto a single fabricated chip about the size of a human fingertip. Intrigued by the potential of quantum computers and their development, I recently visited the National Institute of Informatics (NII) to find out more about their research project to achieve this new and exotic form of information processing.

Their research project began in 2006, and brought together experts in both theory and experiment. The project has now reached an exciting point in its development. I asked NII professor Yoshihisa Yamamoto, the project leader, about the goals of the project. He said, "Our mission is to come up with quantum computing technology capable of expanding its computational scale as required by the tasks at hand. There have been a number of approaches proposed, and tested, around the world so far, however none have been truly successful. This is 'the problem' to solved for scalable quantum information processing (QIP). "

One might ask why quantum computing technology has attracted so much worldwide attention. The main reason can be attributed to Moore's Law, which states that the processing speed of classical computers doubles about every 18 months. The processing power of the machine is limited by how fast information can be transferred between different components on the chip. Information cannot travel faster than the speed of light. The growth of classical computing has followed these concepts, but today's computer circuits are approaching a size where the principles of quantum mechanics are becoming relevant. We can either try and suppress these effects, or use them to our advantage. Either way, unless we have a solution to deal with these quantum properties, the future of semiconductor-based classical computing will come to a standstill. Hence, there is considerable urgency in trying to understand this quantum realm, and how to control and exploit it.

Qubus Computation: a New Route Towards a Scalable Quantum Computer

In 2005, a scheme proposed by a collaborative research group comprising associate professor Kae Nemoto of NII and HP Labs Bristol emerged showing a resource-efficient route towards scalable QIP using photons. The group then built on this achievement, and in the following year announced a theory called "Qubus quantum computation" applicable to a diverse range of physical systems. In particular, light was now utilized as a communications bus between the physical qubits.

I asked associate professor Nemoto to describe Qubus computation. "In this form of computation, quantum bits (qubits), the basic unit of quantum computation, interact via a quantum bus (Qubus) to perform information processing. This interaction is

Yoshihisa Yamamoto
Professor, Principles of Informatics Research Division, NII

Kae Nemoto
Associate Professor, Principles of Informatics Research Division, NII

the building block to be developed, and implemented, in order to construct scalable QIP devices. As the principle of Qubus quantum computing can be realized in many different physical systems, we can expect various experimental demonstrations to be performed utilizing ideas contained in Qubus computation. The successful demonstration of the Qubus interaction will no doubt lead to the development of a device that can be applied to a wide range of QIP; from quantum computation to quantum networks." In short, Qubus has great potential for developing future quantum technologies.

Superconductors Used as Qubits

A highly skilled team was assembled to develop the full potential of the Qubus concept. One part of this team was the Superconducting Quantum Physics Research Group, led by Dr. Kouichi Semba of the NTT Basic Research Laboratory. They are currently working on controlling entanglement, between superconducting qubits, through a single photon. The superconducting qubits, that Dr. Semba refers to as "artificial atoms connected to the external world by conducting wires," are made of microcircuits formed of aluminum. One side of the circuit measures a few microns in length, which is tens of thousands of times larger than the size of a single atom. It has been found that such a system, containing such a large number of atoms, can still exhibit the same quantum mechanical features of superposition (＊1) and entanglement (＊ 2) as those found in a single atom.

As Dr. Semba noted: "Superconductivity is an important behavior where current flows (through aluminum for instance) with zero resistance at temperatures below about 1 Kelvin. In our experiments, a large dilution refrigerator that is more than 3 meters in height is used to lower the temperature to as low as 30 milliKelvin, or 1/10,000 that of room temperature (see the explanation in the photo below)." They use another circuit, called a microresonator, fabricated around the qubit circuit as the Qubus. "A single-mode photon of the microresonator allows qubits to be coupled," said Dr. Semba.

To date, Dr. Semba's group has succeeded in controlling the entanglement between a superconducting qubit and a single-mode photon on the microresonator. They are now starting experiments on different types of qubit gates. I asked Dr. Semba about future issues. "Currently the most important issue is how to implement circuits that are less susceptible to noise. As semiconductor qubits are rather easy to access, they tend to interact with the outer world (environment) through their conducting wires.

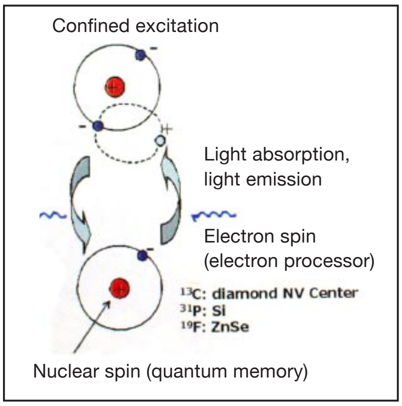
Members of Dr. Semba's group next to the dilution refrigerator. This refrigerator operates at 30 milliKelvin when is an extremely low temperature. The lowest possible temperature is referred to as "absolute zero" and is defined to be 0 Kelvin. Incidentally, room temperature (about 27°C) is equivalent to 300 Kelvin.

(＊1) While a classical bit is either "0" or "1", these values can be partially superposed in the quantum state of a qubit. In the quantum world, a spin can be both in a down state and also in a up state at the same time. Hence, this world can exhibit incredibly rich properties that are difficult to comprehend, as we do not encounter them in our every-day classical world.

(＊2) A phenomenon in which two or more qubits interact to constitute a single quantum state. Entangled states possess a non-local nature, maintaining a single quantum state even when the entangled qubits are spatially separated. Entanglement is a property peculiar to quantum mechanics and plays an important role in most quantum information processing concepts. In particular, quantum teleportation is an entanglement-assisted protocol.

Kouichi Semba
Group Leader, Superconducting Quantum Physics Research Group, NTT Basic Research Laboratory

Kohei Itoh
Professor, Department of Applied Physics and Physico-Informatics, Keio University.



Qubus quantum computing with light as implemented by professor Yamamoto's NII group. This diagram illustrates the exciton states switched by the absorption and emission of light.

We hope to continue engineer improvements to minimize this unwanted interaction."

Stanford Research Group Uses Light for Quantum Computing

At Stanford University, a research team led by professor Yoshihisa Yamamoto is trying to demonstrate Qubus quantum computing with light. According to professor Yamamoto, "Utilizing cavity quantum electrodynamics (cavity QED), we trap electrons in a small cavity (a quantum dot) and generate interactions by shining light into the cavity." The main difficulty in the implementation of Qubus quantum computation using light arises from the nature of light: photons do not usually interact with each other. This is rather opposite to the situation with semiconductor qubits, where the strength of interaction in the system causes unwanted decoherence effects. In professor Yamamoto’s system, a cavity – the quantum dot – is used in order to enhance the interaction between the light and the elections. The light bus can then mediate the information transfer between two cavities.

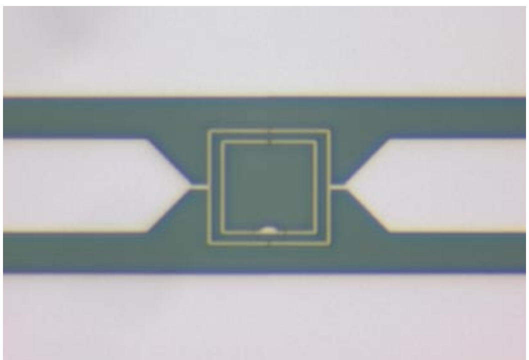


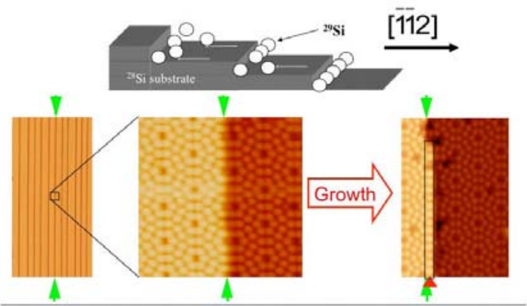
Photo of Dr. Semba's (NTT Basic Research Laboratory) superconducting circuit. Inserted into the dilution refrigerator, at ultra-low temperatures this can be used as a quantum bit.

Professor Yamamoto explains more about their physical system. "We use donor impurities in semiconductor materials, and control the electron spin in there, by applying a light pulse. The quantum state of the electron spin is dependent on whether the electron absorbed or emitted a photon. We can also read out the state difference. The experiments are showing good progress."

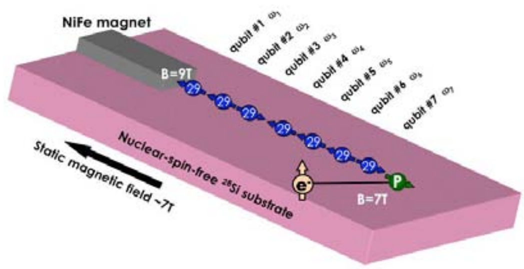
In general, quantum states are known to be fragile. The length of time that the quantum nature of a state can be preserved is referred to as its "coherence time." Professor Yamamoto has made significant strides in lengthening their system's coherence time to about 1 ms, which is quite an improvement. The coherence time determines how many times one can apply quantum controls onto the qubit, and hence limits the number of gate operations in the computation. While it may seem to early to discuss the performance of such quantum computers, professor Yamamoto is looking ahead. "At the moment, loss of light in the cavity is simply too large to implement Qubus as a practical technology. Finding a simple and effective way to avoid this loss, I think, will be a focal point of our future research."

Employing Arrays of Silicon Isotopes

Professor Kohei Itoh of Keio University, another key member of the research project, is known for his research on silicon isotopes. Isotopes are atoms of the same element, differing only in the number of neutrons they have. For example, Silicon has three isotopes: 28Si, 29Si, and 30Si. Professor Itoh's ini-



A conceptual diagram of professor Itoh's (Keio University) 29Si array at the end of a stair-like structure.



Phosphorus for reading spin, attached to the end of the 29Si array (photo provided by professor Itoh).

tial idea was to arrange a row of 29Si within rows of 28Si, which has no nuclear spin, and to construct qubits out of the 29Si nuclear spins. This alone was an unfathomable feat of experimentation.

According to professor Itoh, "There are many things to verify: whether we can initialize individual nuclear spins, whether the nuclear spins can be read out, whether the qubits can perform calculation equivalent operations faithfully..." However, he says with a smile, "We cannot afford to give up at this stage." Questions abound if silicon can be used to implement a quantum computer, given all the current difficulties. Fortunately, there is a vast amount of knowledge concerning silicon fabrication technology that has been accumulated though the growth of classical computer technology; advantages not present with other materials.

In professor Itoh's system, a single phosphorus atom is attached to the end of a 29Si isotope array for read-out. This is the first step in implementing a Qubus system, and significant progress has been made. "We have succeeded in reading out the nuclear spin of the phosphorus by shining light onto it, and observing the wavelength of the emitted light. We have also learned that the nuclear spin can be read using electric current, instead of light," noted professor Itoh.

His research continues to progress well. "We have to understand the quantum nature of the system before we begin to discuss whether to use it, or suppress it. Our process is important as basic research, but we also hope to tie our research to industrial applications."

The Road to a Quantum Computer

When the project ends in two and half years, what prospects will have been unveiled along this road to a quantum computer?

In addition to collaborating with each of these experimental groups, associate professor Nemoto, who is a theoretical physicist, also investigates the potential of Qubus for constructing future quantum technologies, and potentially a large-scale computer. The role and benefit of theory is to provide new ideas that show possible fundamental breakthroughs, and to direct new ways to step forward towards final goals. According to associate professor Nemoto, "In measurement-based quantum computing, Qubus computation has shown a number of advantages, such as its resource efficiency, as well as its robustness against photon loss. We are now studying various device designs, as well as applications, that will exploit these properties to their utmost."

It appears that the theory of Qubus has made tremendous progress, even exceeding the impact of its initial announcement. Associate professor Nemoto added, "Measurement-based quantum computing requires a huge number of qubits, so for such a system photons might be the ideal candidate as photons can be cheaply generated based on the demand. In fact, we have found that Qubus techniques can be incredibly effective in such systems."

There are many interesting ideas arising from this project, which may provide new methods of quantum information processing. I look forward to following the project's future progress.

(Reported by Rue Ikeya)

NII SPECIAL

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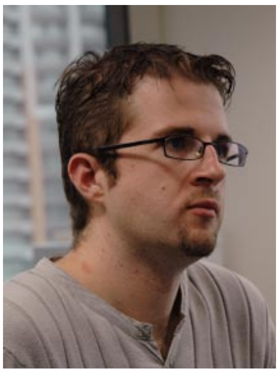
The NII Quantum Information Science Theory Group: The Global Standard in Theory

NII's Quantum Information Science Theory Group, headed by Associate Professor Kae Nemoto, is carrying out theoretical research on quantum information and quantum computation. The group has an international base, allowing it to engage in various collaborations with leading overseas researchers and professors in quantum information science. The group's seminars make effective use of these international ties, as does its inclusions of postdoctoral fellows invited to join the research group. Its lively exchanges also include sending researchers to other centers. The group's regular meetings take the form of one of the member's reporting on his or her current research results. Instead of merely reporting results however, the researcher uses the meeting to seek views on problems he or she is currently facing, so that it becomes a critical opportunity to deepen understanding. At one of these meetings, which are held roughly once a week, we asked members about the significance of participating in the group, and the research environment NII provides.

Kae Nemoto
Associate Professor
Specializes in theoretical physics, quantum information, and quantum computation. Group leader.



Simon Devitt
Simon, coming from the University of Melbourne and the University of Cambridge, is participating in the group as a postdoctoral fellow.

How to conduct international research in Tokyo

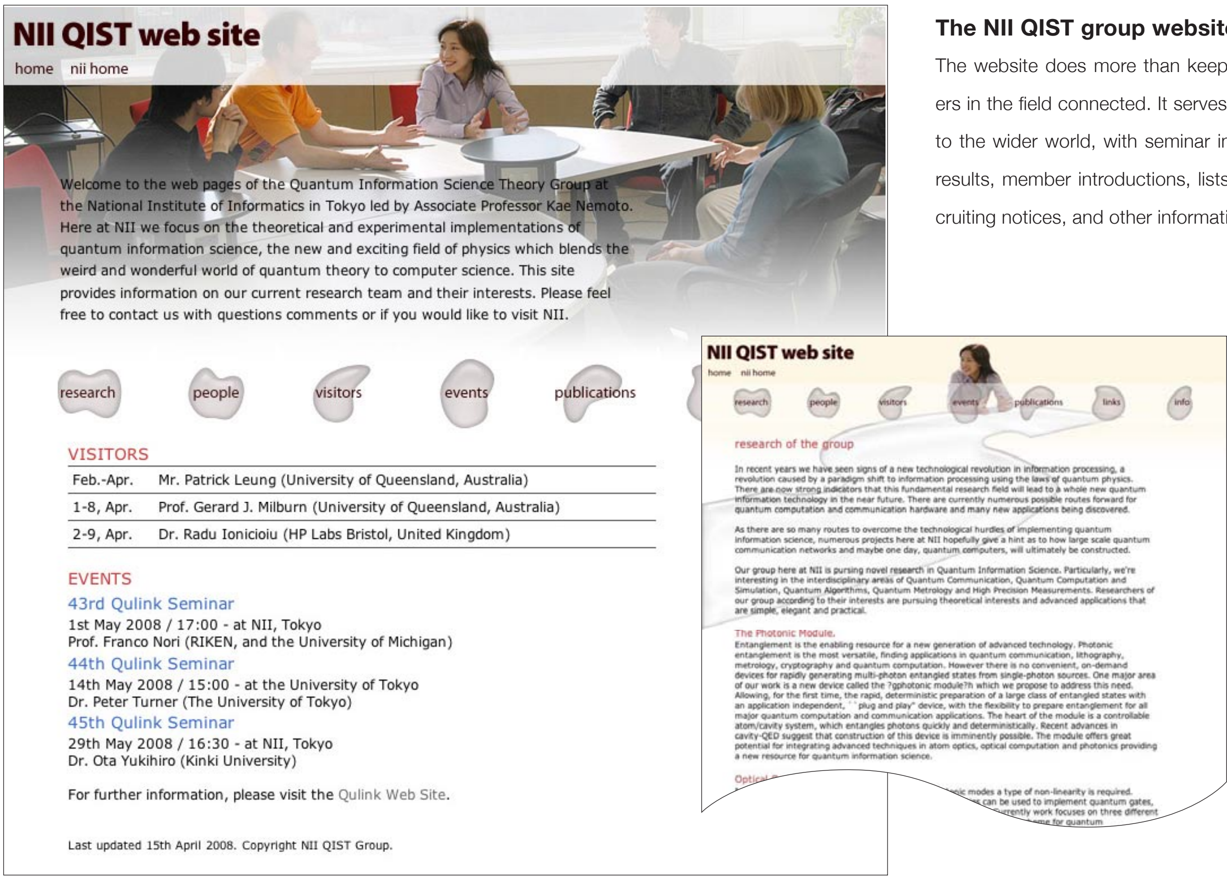
Jun: I chose this group because it includes a fairly large number of post-docs. I thought it would be an environment in which it would be easy to engage in discussions related to my own research, and to do joint research. I've always enjoyed talking with people whose interests are adjacent to my own, and that's been a major source of energy for my work. Another reason was that Kae is conducting a broad range of collaborative work with outstanding research groups throughout the world.

Todd: Same with me. I had left research to work as a technology analyst, but when the opportunity to work with Kae and her group came, I returned to research. That's how attractive the group is. There are very few people like Kae who are conversant with both research in Japan and trends overseas, as well as being able to keep significant projects moving forward.

Toki: In my case, until two years ago, I was in the Mathematical Institute of Tohoku University, and before that at Hokkaido University. At both Universities, I quickly began to see the same people, and go to the same places, every day. Because part of the job of being a good researcher is knowing when to change your environment - I had decided I needed a change - so I came here.

An environment offering both freedom and everything the researcher needs

Toki: When I joined the group, I was struck by how different the members are from the people I'd known at University. Their style in carrying out their research was different. They have their own network of collaborators, of all sorts, beyond their own research field. And they are great at giving presentations. But the biggest difference is that here we have to find our own research topics and pursue them - we are given that freedom. Sometimes I am not quite sure how to handle such freedom, but I am trying because I know it will pay off in my future research career.



The NII QIST group website

The website does more than keep members and others in the field connected. It serves as the group's face to the wider world, with seminar information, research results, member introductions, lists of publications, recruiting notices, and other information.

Simon: My feelings are this. While working on my doctorate (at the University of Melbourne in Australia), I spent a year doing research at Cambridge. Both institutions gave me a lot of freedom in my research, but nothing like the freedom I have at NII. At Melbourne, I did a large amount of work in solid-state physics, and at Cambridge I was basically working in conceptual quantum physics. So what I wanted, as Toki noted, was freedom. Here I have an environment where I am free to do my own research.

The work I want to concentrate on is creating a device that will be the basis for making quantum computing a reality - well, I suppose everyone in quantum information science research is thinking the same way! I found the perfect environment that frees me to concentrate on that within Kae's group. In fact, I really like the research environment here at NII and don't see myself leaving anytime soon.

Informatics at NII open up new possibilities

Jun: Now that I have actually experienced it, I feel NII is very different from the way general Universities are run. Of course, there are both good and bad aspects to that difference. Before coming here, I worked at the National University of Singapore in its Faculty of Science. There, I had opportunities to talk informally with many other physicists and, through participating in weekly seminars, benefited from hearing very interesting discussions on what was happening in other fields. At NII, the environment is in place for me to focus on my research. That's great, but I do sometimes miss the comradery of the University.

Casey: There's not much more I can add. I came here to do some good research in a serious research group. I do miss being in a University physics department - like Jun - but at the same time, being in this group makes it all worthwhile.

Todd: You know, NII really does focus on Informatics, and that makes it a remarkably unique research institution. As members, we can meet specialists in all sorts of fields, including bioinformatics, quantum informatics, and web search technologies, for example,

Todd Tilma
Todd, coming from the United States, is participating in the group as a postdoctoral fellow.

Jun Suzuki
Jun is the newest member of the group, who had just arrived at NII when he was interviewed.

Compute by “Cooling” Quantum System

Tokishiro Karasawa
Toki came to NII from Hokkaido University and Tohoku University.

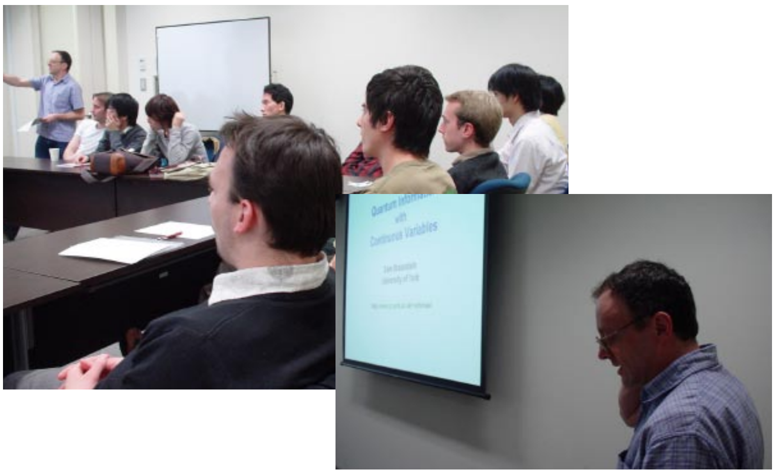
and learn what is going on in their research. This environment is truly what distinguishes NII from others. No ordinary University could provide this. And on top of that, NII is located right in the middle of downtown Tokyo, my favorite city.

Those are the reasons that NII has the potential to produce utterly new and challenging research. For example, how about using quantum informatics theory in web searches, or applying simulation techniques to bioinformatics. Those are fascinating ideas. I want to engage in collaborations like that and, if they lead to new discoveries with academic significance that also have an impact on the business world as well, that would be even better yet.

Toki: Actually, I think quantum ways of thinking are going to become increasingly important. But, I feel that currently there is a gap between quantum researchers and people in other fields. I think it's our job to fill in that gap, whenever the opportunity arises, by communicating the value of quantum physics to other researchers at NII who might not be too clued into it.

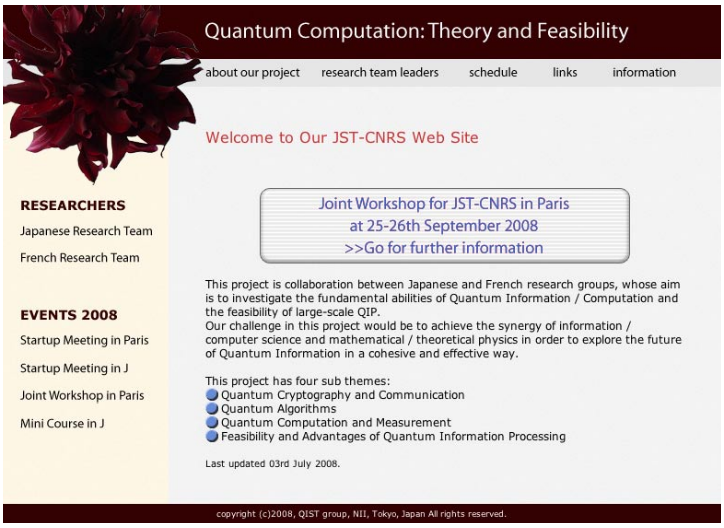
The Qulink Seminar and the Japan-France joint workshop

Sebastien: My reasons for choosing this group are not much different from everyone else's. For a student, the open houses that NII holds are a great chance to learn what other students are doing. And, the welcoming party that NII organized when I started my new research life here really helped smooth things out for me, especially at the beginning when



Qulink Seminar

Launched in 2004, the Qulink seminars are a seminar series jointly organized by the NII QIST group and the University of Tokyo. With, as a rule, two seminars a month, it will hold it's fiftieth seminar in 2008. In the photograph on the right, Professor Gerard J. Milburn of the University of Queensland, Australia, is presenting at a Qulink seminar in 2004. The two photographs on the left show Professor Samuel L. Braunstein of York University in the United Kingdom speaking at a 2006 seminar.



The Japan-France Joint Workshop

The Japanese team, lead by Associate Professor Kae Nemoto, and the French team, lead by Dr. Iordanis Kerenidis, are engaged in this collaborative effort in quantum information science. To facilitate smooth and effective collaboration, they have set up a website that is proving useful in the exchange of ideas. A join workshop will be held in France this coming fall.

there were still a lot of unknowns for me here.

The Qulink seminars have also been a big help to my studies. They have helped me clear thing up when I hit a conceptual snag in my own research, and has provided me good guidance about fields that I was not too knowledgeable about. Of the seminars that I have participated in so far, it was the lecture about linear optics by Tim Ralph (a visitor from the University of Queensland, Australia) that made the most vivid impression on me.

Simon: Yes, I think the Qulink seminars are extremely valuable. So much so that I think holding the seminars more often might be a good idea. I think it is more meaningful to hear new ideas directly instead of waiting until the paper comes out.

Kae: As Simon just said, seminars and workshops are opportunities to have faster contact with new ways of thinking. Sometimes they provide insight when the person doing the research may not have yet realized how brilliant his or her ideas are. The Qulink seminars always provide plenty of time for free discussion after the presentation. I want students to ask all the questions they wish at these events - that's what being in touch with the leading edge means. It's about identifying yourself as a researcher early on and really getting down to it, even though there are all sorts of things you don't understand, or areas you need to study more. I think that is the approach that gives rise to outstanding researchers. So, yes, let's definitely consider having more seminars.

The future of quantum information science

Kae: This year, we are holding a joint workshop with a French quantum informatics team. First, the Japanese team (us) held a workshop at NII last March. Then the French team held their kickoff meeting in Paris last June. The main workshop is yet to come.

Simon: I'm looking forward to that meeting, scheduled to be held in Paris this autumn. I know British and German researchers, but chances to know what is going on in quantum informatics in France are few and far between, so that workshop is going to be a very valuable experience.

Kae: What do you think the outlook for research in quantum information science is?

Sebastien: I expect to see all sorts of useful quantum technologies emerging in the near future. That is why we need to do solid, theoretical, mathematically sound research on quantum information science now.

Simon: What I am aiming for, of course, is a large-scale quantum computer. Is that an achievable goal? I was asked that same question two years ago, and I said that, honestly speaking, it was going to be pretty difficult. But now I am quite optimistic. Think about it: In the 1980s, who could even have imagined the personal computers we are now using? Working with a group of researchers like this, I know that we can make the quantum computer happen too. (Reported by Rue Ikeya)

Casey R. Myers
Casey came to NII from the University of Waterloo in Canada.

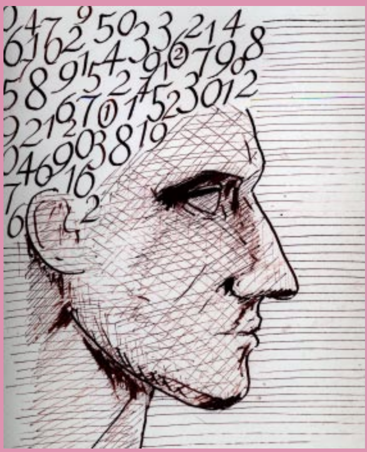
Sebastien Louis
The youngest member of the group, he is a Ph.D. student in the Graduate University for Advanced Studies (SOKEN).

NII ESSAY

Is the Science of Statistics a Sin?

Noriko Arai
Professor, Information and Society Research Division, National Institute of Informatics

Looking through the Old Testament, we often come across statements that are mysterious for modern people. The most obvious is the one about Adam, the father of humankind, being 930 years of age. This of course can be seen simply as an exaggeration, but there is an even more enigmatic statement later on. This is a description of the grave sin committed by David, the hero of Israel.



Population Census Becomes a Sin

King David won many battles against the Philistines and other neighboring tribes and expanded his land much more than before. Satan then appeared and "provoked David to number Israel." No doubt the experienced and wise David knew intuitively that in order to achieve victory, it was most important to accurately understand the number of men, in other words, the number of soldiers, at his disposal. Refusing to lend an ear to the words of his underling, who opposed the numbering in fear of God's wrath, David forcefully carried out the first ever population census. God was very displeased and, as a punishment, offered David the choice of three things: "Either three years' famine, or three months to be destroyed before thy foes, or three days of pestilence in the land." David chose the three days of pestilence, as a result of which 70,000 men lost their lives.

For people like us living in modern times, the idea that a population census is a sin is more than mysterious, it is a shock. Moreover, the punishment handed down by God suggests that the sin was seen as even graver than the crimes of theft and murder.

The Bible seems to take it for granted that carrying out a population census is a sin. While it is impossible to completely understand why a population census is a sin, a hint can be found in the words of David's underling who opposes the census: "May the Lord multiply his troops a hundred times over." In other words, wishes for an increase in the number of soldiers or for a bountiful harvest that year were simply prayers, and these were considered to be domains that should be entrusted to God. Conducting a population census yourself and deciding such matters as "we could beat the Philistines if we had such and such a number of soldiers" or "next year's tax revenue would amount to so much if we had this number of people" was thought to be a great sin against the territory of God. The impact of this reference was substantial. Even in the eighteenth century, there were quite a few pious members of the English Parliament who cited this story in the Old Testament as a reason for opposing a population census bill.

What Would God Think of Forecasts Based on Statistics?

Turning our attention to the present, I cannot help but wonder how God looks on humankind in this age of petabyte data, when we make such forecasts as "the average temperature on Earth will rise by two to four degrees over the next century" and "there is a 70% probability that an earthquake with a magnitude of over seven will occur in southern Kanto in the next 30 years."

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