Global Research Center for Quantum Information Science National Institute of Informatics

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ABSTRACT

The Global Research Center for Quantum Information Science was established in 2008 to conduct and support research in the field of quantum information science and technology. Our center's focus has been on the merging of two fields: quantum physics and computer science. It has been nearly ten years since its establishment and its development has accelerated even further as this field moves into the near term era of noisy intermediate quantum computers. The center is now making a necessary and important phase transition to establish quantum computer science.

INTRODUCTION

To begin, the National Institute of Informatics (NII) is a research institution for "informatics", not for "physics". It is the only institute in Japan dedicated to informatics, and hence it can accommodate physics-related subjects. NII covers a wide range of scientific and technological research fields, ranging from computer science, data-based social science, logic, mathematics to quantum information & computation. While NII is a research institute, it is not a national laboratory and so its establishment was to foster, serve and support inter-university collaboration. As such it is an academic establishment that might be considered unique around the world. There are fifteen inter-university research institutes in Japan and NII is one of them.

NII consists of four primary divisions: the Principles of Informatics Research Division, the Information Systems Architecture Science Research Division, the Digital Content and Media Sciences Research Division, and the Information and Society Research Division. There are 80 faculty members and 115 researchers; 33% of the researchers are from overseas with 20% being from Asia. [1] Almost all of the "physicists" are located in the Principles of Informatics Research Division, whereas the center itself is merging all disciplines for quantum information and computation across the fields.

The Global Research Center for Quantum Information Science

The Global Research Center [2] for Quantum InformationSscience might be looked upon as a group of physicists surrounded by computer scientists moving into the CS domain. Physics has done such bridging of fields for many years (or even decades), and although quantum computation started mostly with physicists, if the field is successful, it would establish quantum computer science in the future. In 2008, the idea of quantum computer science was a bit too early, nonetheless the research center was established. In fact, NII's efforts in quantum information and computation began in 2003. Around that time, quantum information science was still quite new in Japan, and to create a quantum community we started a seminar series "Qulink" [3], which is a quantum link for quantum people. NII together with the University of Tokyo hosts two seminars every month, and we had the 161th seminar last November.

The focus of our center has been on quantum physics, that is hardware development for quantum information devices and systems, the architectural design for quantum computation and communication, quantum sensing and novel quantum properties. We consider such fundamental research critical for NII, and our collaborations with industry help us with this. Although our motivation is in physics, the sense of informatics naturally arises from our research. This is simply due to the interdisciplinary nature of the field. Since 2008, we have seen huge developments in the fields of quantum information and quantum computation. We are experiencing the emergence of small-scale quantum systems such as IBM-Q. Although it is still too primitive to call such a systems a quantum computer, a quantum coherently controlled system with dozens of qubits has never been achieved before and has the potential to allow the testing of small scale quantum algorithms. It is clear that we are entering a new era of quantum science and technology.

At NII, our focus has been to extend the theoretical capabilities of quantum information technology and to test their feasibility. In many applications such as quantum computation, communication and sensing, it is vital to design new schemes to exploit quantum supremacy, which brings us a deeper understanding of quantum physics. At the same time, it is necessary to understand what is feasibly, both realistically and ideally.

In particular, NII has been leading research in the architectural design of quantum computers and repeaters (quantum repeaters are the core technology for quantum communications) and the implementation of these building blocks.

We are now pushing these investigations further, with our move towards to "quantum computer science". Even so, we are still exploring fundamental quantum physics to give us a better understanding of its possibilities and limitations in quantum information science.

International collaborations

As our center has only a small number of core members, international collaboration is criticial. Fortunately, NII strongly supports international collaboration, and the Global Liaison Office (GLO) helps us to organize these activities. For instance, NII has a program to invite collaborators from overseas and hosts intern students for periods of two to six months.

We also organize (co-organize) a serious of workshops on different topics such as quantum computer architectures, quantum metrology, implementation of quantum systems, to highlight a few. The most recent one was a JSAP conference on challenges in quantum information science and technology (CQIS2018) that we organized and co-sponsored last April. [4] This conference was unique among all the conferences/workshops we have organized or maybe even all the physics conferences worldwide. It was dedicated not only to quantum science and technology but also to our future research community and the future society that quantum technology would bring. In the conference, all plenary and invited speakers were female researchers. It is wrong to think that this conference is for women, as it is equally wrong to think that all other conferences are for men. We wanted to change the attitude of how to select invited/plenary speakers. By abandoning the stereotypical attitude of "gentlemen

Fig. 2: CQIS2018 CQIS was held in the Hitotsubashi Hall last April.

first" in physics, this conference proved that there are many (and maybe too many) excellent female researchers that one can invite to such a conference. Perhaps it was telling us what we need to do is not to include female researchers, but not to exclude them. As a result of this conference, the participants enjoyed not only invited/plenary talks but also contributed talks that were, of course, equally from both genders, along with scientifically deep and insightful questions and discussion. [5] The gender balance for this meeting was approximately 50/50 which has been unheard of in this community.

Maybe we are looking at gender imbalance in physics from the wrong angle. Maybe overcoming the unconscious bias is not that hard an exercise. Actions based on observation and data should certainly help.

PhD students and opportunities

While NII is a research institute, it also hosts the Department of Informatics for Graduate Education. This is another unique feature of the inter-university research institutes in Japan. The fifty inter-university research institutes together form a graduate university, the Graduate University of Advanced Studies (Sokendai) where each institute hosts such a department. [6] Sokendai is, of course, older than NII as it celebrated it's 30th anniversary in 2018. It is designed so that students conduct their research in an international and high-standard research environment provided by the host research institute. As the host institutes do not accept students without a degree, Sokendai does not have undergraduate students. There are only two courses: a five-year course for students without a masters degree and a three-year course for students who alreafy hold a masters degree. There are a number of programs in Sokendai to support students to pursue their carrier. The national scholarship program, which aims to attract students particularly from Asia, was newly funded from this year. Also, our department has its own scholarship program for students from overseas as well as a research assistant system to financially support students. About a third of students in our department are from overseas.

Future directions

Diversity and equality are important for the Global Research Center for Quantum Information Science. The center inherits the international nature of NII and Sokendai, and our door is always open to collaboration. In fact members of the Center are from many different countries and Japanese are barely in the majority. Four out of five visiting professors in our Center are from overseas. The majority of the research in the Center involves quantum physics at a deep level, however the people there have different backgrounds. To push quantum information science, we need a variety of skills and expertise. In the last year, we have developed new collaborations with the computer science sector and we are now working towards establishing solid foundations for quantum computer science.

References

[1] http://www.nii.ac.jp.
[2] https://qis1.ex.nii.ac.jp/.
[3] https://qis1.ex.nii.ac.jp/qulink/.
[4] https://qis1.ex.nii.ac.jp/workshop/CQIS2018/
[5] http://www.iopblog.org/report-after-report-shows-global-under-representation-of-women-in-science/.
[6] https://www.soken.ac.jp/en/.

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