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Superconductivity Technology Opening Terahertz Astronomy

—World's highest level of receiver ALMA Band 10 realized with niobium titanium nitride superconductor—

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NICT Fellow

After completing a doctoral program, WANG joined Communications Research Laboratory, Ministry of Posts and Telecommunications (currently NICT) in 1991. He has been engaged in superconducting electronics research. He is currently Professor of Shanghai Institute of Microsystem And Information Technology, Chinese Academy of Science. Ph.D. (Engineering).

UZAWA Yoshinori
Associate Professor of National Astronomical Observatory of Japan

After completing a master's program, UZAWA joined Communications Research Laboratory, Ministry of Posts and Telecommunications (currently NICT) in 1991. After engaging in research on terahertz band superconducting receivers, he joined the National Astronomical Observatory of Japan in 2005. He currently serves as the leader of the ALMA Band 10 and Band 4 development team and is also Associate Professor of The Graduate University for Advanced Studies. Ph.D. (Engineering).

MAKISE Kazumasa
Researcher, Nano ICT Laboratory, Advanced ICT Research Institute

After completing a doctoral program and serving as Researcher of National Institute of Materials Science, MAKISE joined NICT in 2009. He has been engaged in research on superconducting thin film properties and superconducting electronics. Ph.D. (Science).

What is ALMA?

Figure 1 Recently-completed ALMA telescope (taken on March 14, 2013)

In the Atacama Desert of South America Chile 5,000 m above sea level, ALMA (Atacama Large Millimeter/submillimeter Array) radio telescope, which is a global collaboration among East Asia, North America, and Europe, was completed at last (Figure 1). ALMA is composed of a total of 66 parabola antennas (54 antennas 12 m in diameter + 12 antennas 7 m in diameter). It is called an "interferometer" because the interference of radio wave signals received via each antenna from celestial objects can be created, making the group of 66 antennas function as though they are one large telescope. The interferometer's performance is represented by its telescope visual power (resolution), which is determined by the distance between the farthest separated antennas (baseline length D) and ratio of observed wavelength λ (λ/D). Just the name "Large" suggests, ALMA has a maximum baseline length of 18.5 km (the size of Tokyo's Yamanote Line) and realizes an impressively high resolution that is approximately ten times the resolution of "Subaru Telescope" and "Hubble Space Telescope" by decreasing the wavelength of observed radio waves to sub-millimeter waves (–300 µm). Moreover, because it can realize high sensitivity that exceeds that of existing radio telescopes by over 1 order of magnitude, it is expected to shed light on important scientific problems one after another which have yet to be explained in astrophysics, astronomy, planetary science, and other areas.

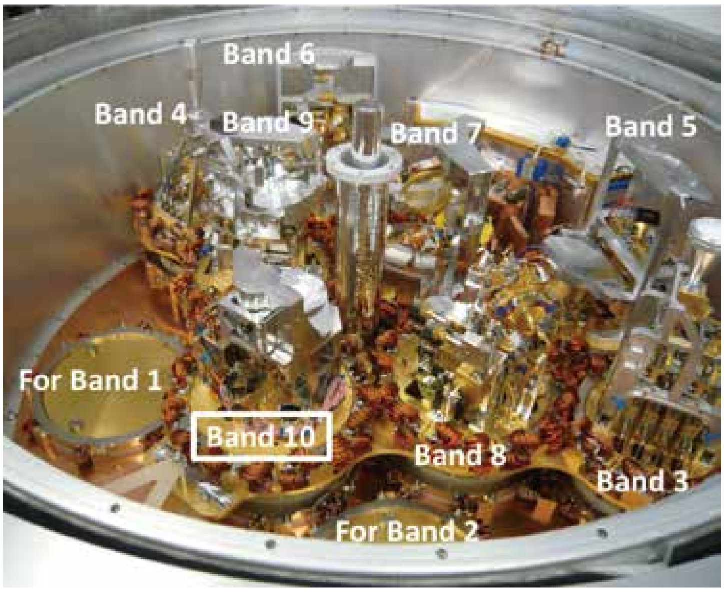


Figure 2 Receivers installed into an ALMA cryostat (container that cools to 4K(-269°C)). Band 1 and 2 are not installed yet.

ALMA receiver and superconducting technology

ALMA's observing frequency range is 31.5–950 GHz, which we divide into 10 frequency bands and observe with 10 receivers shown in Figure 2 equipped on each antenna. Because it is not possible to directly amplify sub-millimeter wave/terahertz-band signals with current technology, received signals gathered with antennas are mixed with local oscillator signals by a non-linear element known as a "mixer" and down-converted to low frequency signals of around 1–10 GHz. This is called heterodyne conversion. Heterodyne converted signals are called Intermediate Frequency (IF) and can be amplified with present microwave technology. Superhigh frequency, ultrasensitive heterodyne receivers are necessary in order to realize superlative radio telescopes like ALMA, and with the mixer at the heart of this, superconducting thin film technology and device technology play central roles.

The SIS (Superconductor Insulator Superconductor) mixer, which uses superconducting technology, can in principle achieve

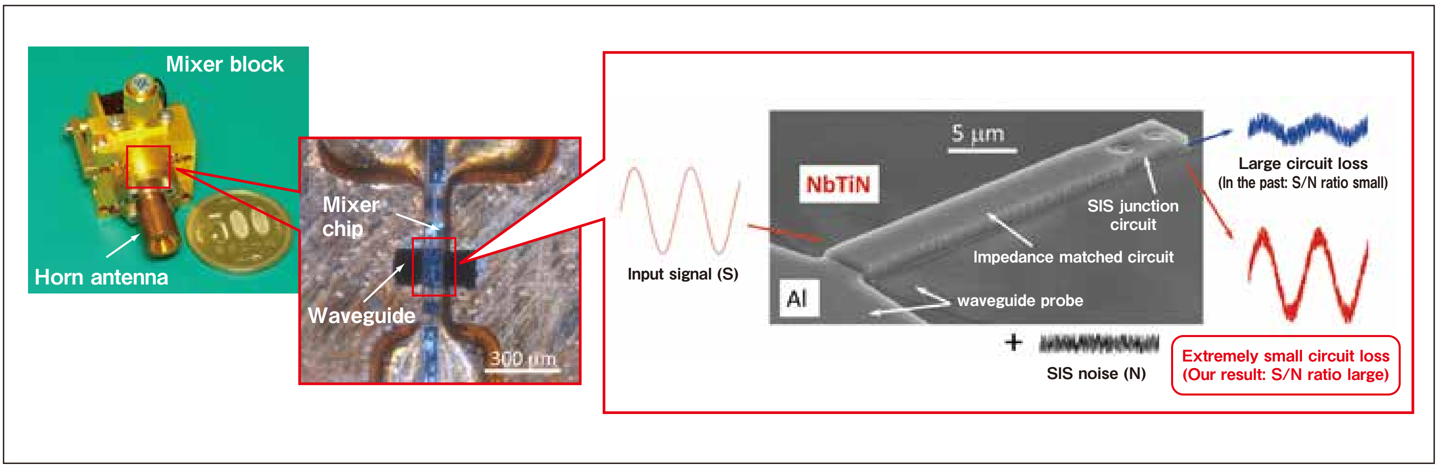


Figure 3 ALMA Band 10 mixer
(Left: Mixer block photo, Center: photo of optical microscope inside block, Right: scanning electron microscope photo of a superconducting integrated circuit that uses NbTiN thin film)

ultimate high-sensitivity that approaches "quantum noise" theoretical limits. For this reason, it had been installed on an astronomical telescope and practically used as a highly sensitive electromagnetic wave receiver since the 1970s. However, in the development of ALMA, there was a fundamental issue in the highest frequencies (787–950 GHz) called "Band 10" that existing superconducting technology could not be applied. This was because the superconducting material that constitutes SIS mixer elements. In SIS mixers of up to Band 9 (602–720 GHz), pre-existing superconducting material, niobium (Nb), is used for which fabrication technology is already established. However, there is an inherent operating frequency limitation that exists in superconducting material called "gap frequency". In the case of Nb, this is approximately 700 GHz. Because the superconducting state starts to break down above this frequency and deterioration of superconducting high-frequency circuit used in mixers increases, receiver sensitivity becomes extremely poor. Therefore, in the case of Band 10, the challenge is that we must newly develop an SIS mixer by using a superconducting material with gap frequency at least above 1 THz (1,000 GHz) instead of conventional Nb.

At NICT, in an effort to effectively use this terahertz band, an unexplored electromagnetic region, as a frequency resource, we have conducted research and development since the 1990s on niobium nitride (NbN) superconducting thin film technology with gap frequencies of 1.2–1.4 THz and its device technology. It is expected that these technologies will be applied in Band 10 receivers. Also, development of an SIS mixer for ALMA Band 10 that uses NbN superconducting thin film started in 2006 via collaborative research with the National Astronomical Observatory of Japan.

Achieving the highest performance in the world

Figure 3 shows a Band 10 SIS mixer being used at ALMA. Astronomical signals received with parabolic antennas ultimately enter a horn antenna of a mixer block that is cooled at 4K(-269°C). The signals are transmitted from the horn to the waveguide and then to the mixer chip. Next, the signals are detected by a diode called SIS tunnel junction embedded in the superconducting integrated circuits on the mixer chip. Conventionally, large high frequency loss occurred in superconducting integrated circuits, which resulted in attenuation of the signals. However, by using niobium nitride titanium (NbTiN) developed at NICT, we successfully produced circuits with extremely small losses even in the terahertz band. Figure 4 shows the performance of Band 10 receivers produced in the past. The required specifications [sensitivity less than 5 times that of quantum noise] for ALMA were considered difficult to achieve before, but we have made it possible with all the receivers we have produced.

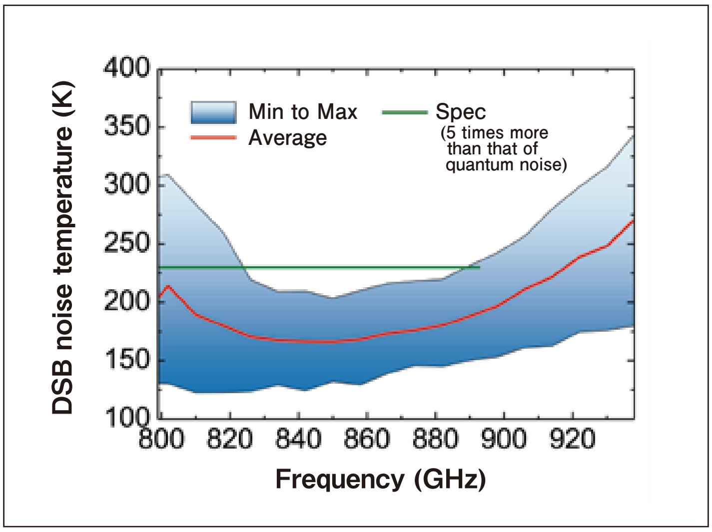


Figure 4 Noise performance of Band 10 receiver produced in the past

Future prospects

Reliable NbN superconducting technology that makes "mass production" possible like ALMA is one of many achievements from fundamental research NICT has worked on for over 15 years. In recent years, this NbN superconducting technology has been playing a major role in new areas of single photon detection such as quantum information communications that underpins future information communications society and also quantum optics.

This achievement was the result of support and cooperation from ALMA affiliates in Japan and abroad, and people from Osaka Prefecture University and Purple Mountain Observatory, Chinese Academy of Science. We would like to take this opportunity to express our gratitude to you all.

Watching Radio Waves with Light

—Making reference signals with light to receive high-frequency radio waves—

KAWANISHI Tetsuya

Director of Lightwave Devices Laboratory, Photonic Network Research Institute

After completing a doctoral program and serving as Post-Doctoral Researcher of Kyoto University Venture Business Laboratory, KAWANISHI joined the Communications Research Laboratory, Ministry of Posts and Telecommunications (currently NICT) in 1998. He is currently engaged in research on optical modulator devices, millimeter wave and microwave photonics, and technology for high-speed optical fiber transmission. He was a Guest Researcher of University of California, San Diego in 2004. Ph.D.(Engineering). IEEE Fellow.

KIUCHI Hitoshi

Associate Professor of National Astronomical Observatory of Japan

KIUCHI joined the Radio Research Laboratory, Ministry of Posts and Telecommunications (currently NICT) in 1982. He is currently engaged in research on Very Long Baseline Interferometry (VLBI) data acquisition, real time correlation processing, and standard signal regions. In 2004, he transferred to the National Astronomical Observatory of Japan where he engages in research on ALMA photonic reference signals. Ph.D.(Engineering).

Using light to capture high-frequency radio waves

We can see stars when gazing up at the night sky, but what are we seeing? Of course, light given off by stars. ALMA, however, does not watch stars with light but instead with radio waves. It uses radio waves—millimeter-waves and terahertz waves (also called sub-millimeter waves)—that are smaller (wavelength) than those used in cellular phones and televisions with many vibration frequencies per second (frequency). Millimeter-waves refer to radio waves with wave lengths between 10 mm to 1 mm and frequencies within 30 GHz to 300 GHz. Incidentally, radio waves used in cellular phones have frequencies of approximately 1–2 GHz. As you know, radio waves and light are both electromagnetic waves and differ only in frequency. Terahertz waves are electromagnetic waves with higher frequencies than millimeter-waves and share the same properties as light and radio waves. However, there have been issues with millimeter-waves such as the difficulty in making and quickly distributing complex signals with conventional technology. This is because loss in the conductor for transmitting electric signals rapidly increases with frequency, resulting in efficiency loss in conventional electronic parts and cables. ALMA is solving this issue by generating/delivering via optical technology reference signals needed for receiving these types of extremely high-frequency millimeter-waves/terahertz waves with high precision. With optical fiber, we can efficiently transmit high frequency signals over 100 GHz, allowing us at NICT to succeed in generating stable 470 GHz optical signals using an original optical device.

Generating and distributing reference signals with light for receiving radio waves

At ALMA, many antennas are interlinked to increase reception sensitivity. In order to accurately time each signal, millimeter-wave (reference signals within a wide frequency range from 27 to 122 GHz) generation and transmission technology that uses light on 66 antennas separated a maximum of 18.5 km

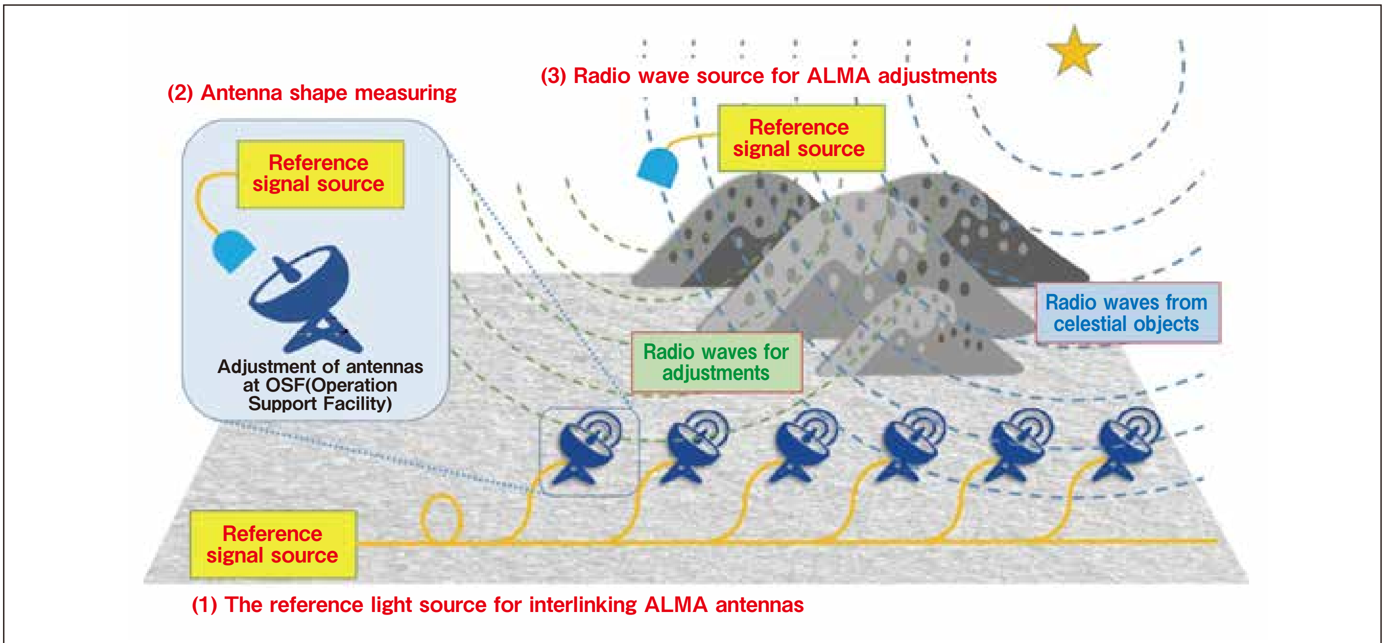


Figure 1　Reference signal source used at ALMA

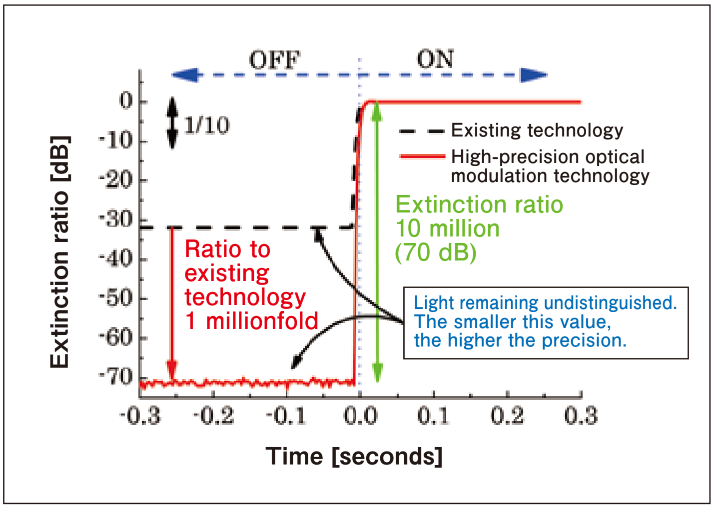


Figure 2 On/off of a light based on high exinction ratio modulation

Figure 3 Central ALMA seen from the planned artificial signal source site for calibration
(photo provided by National Astronomical Observatory of Japan)

Figure 4 Reference light generator for characteristic measurement of photonic detector frequency
(photo provided by Trimatiz Limited)

is being used (Figure 1 (1): the reference light source for interlinking ALMA antennas). Reference optical signals—signals that alter light intensity with millimeter wave optical signals of predefined frequencies—are sent via optical fiber efficiently to each antenna. On antennas, millimeter wave signals are taken from reference optical signals and then used for receiving faint signals from celestial objects. Based on NICT technologies (high-speed and high-precision lightwave modulation technologies) developed for optical communications that generate optical signals with high precision, NICT and the National Astronomical Observatory of Japan (NAOJ) conducted collaborative research on reference signal generation technology. NAOJ jointly developed reference signal generation units designed for ALMA in cooperation with American and Taiwanese researchers. The extinction ratio, which shows the intensity of lights that remain unextinguished, is an index of light modulation accuracy. Although modulator extinction ratios over 100 have been considered large enough for applications, NICT succeeded in developing technology that drastically improves upon this, realizing extinction ratios over 10,000,000 (Figure 2). This made possible the generation of stable, high-speed, high-quality reference signals.

This technology is not only used to interlink ALMA antennas but also as reference signals for measuring the shape of 7 m-diameter antennas with 4.4 µm precision and is making large contributions to the performance retention of the 66 ALMA antennas (Figure 1 (2): antenna shape measurement). Manufacturing tolerance of antennas should be less than10 µm, much smaller than the diameter of a hair, requiring precise measurements to compensate for changes due to the severe outside environment.

There is a plan to use high-precision optical modulation technology on top of a 5,300 m mountain where the reference signal source (artificial calibration source) (Figure 3)—for adjusting ALMA—is located, even higher than ALMA which is located at an altitude of 5,000 m (Figure 1 (3): Radio source for ALMA adjustments). With a higher altitude than ALMA's main unit, it is located in severe conditions such as it requires solar panel to secure its power and may become the world's highest altitude-installed high-speed optical modulator. Looking at Figure 1, you can see the three critical roles the reference signal source used at ALMA has which are: driving ALMA's itself, adjusting each antenna, and adjusting the ALMA as a whole.

Taking optical technology developed at ALMA to familiar places

Reference signal generation technology developed for ALMA began being used in practical communication systems. Development of application technology is also being advanced for photon detector performance measurement that converts optical signals to electronic signals (Figure 4) and radio wave measurement for using millimeter wavebands now starting to be widely used. At NICT, we are advancing international standardization activities related to measuring methods of optical modulators and photon detectors at IEC (the International Electric Commission). It is becoming clear that modulation with a high extinction ratio is crucial for realization of advanced modulation format based telecommunication systems as well as ALMA reference signal generators. ALMA, itself, is not for daily life applications, but it is fair to say that the development of this reference signal generation technology shows that continuous advanced research would bear daily life or industry applications.

[Acknowledgements]

Research related to high-speed and high-precision lightwave modulation technologies has been conducted with the cooperation and collaboration of researchers in Japan and abroad. I would like to express my gratitude to everyone at the research institutions and universities who helped including: Osaka University, University of Hyogo, Waseda University, Doshisha University, Chiang Mai University, the National Institute of Advanced Industrial Science and Technology, KDDI R&D Laboratories, Anritsu Electric Corporation, Trimatiz Limited, Sumitomo Osaka Cement Co., Ltd., and Bell Laboratories, Inc.

Amplifying and Regenerating Optical Signals to Distant Locations Using Quantum

—Successful demonstration of new "relay amplification technology" that extends quantum communication distance range—

SASAKI Masahide

Director of Quantum ICT Laboratory, Advanced ICT Research Institute

After completing a doctoral program, SASAKI joined NKK (currently JFE Holdings, Inc.) in 1986, where he engaged in research and development on semiconductor memory. He later joined Communications Research Laboratory, Ministry of Posts and Communications (currently NICT) in 1996, where he has been engaged in research and development on quantum information communication. Ph.D. (Science).

Introduction

Current information-communications systems are designed based on classical mechanics such as electromagnetics and optics. However, by applying the rules of information manipulation to quantum mechanics, we can realize unbreakable secure communications (quantum cryptography) and ultimate low-power, high-capacity communication (quantum communications).

In quantum cryptography, cryptographic keys are transmitted with bit information placed on photons*1—particles of light. Based on the uncertainty principle, eavesdropping operations on photons will always leave traces, allowing cryptographic key eavesdropping to be detected with certainty. With quantum communications, implementing super parallel processing while converting received optical signal pulse trains to a quantum superposition state where bit patterns concurrently exist overcomes classical communication theory limits (Shannon limit). This will allow high-capacity communication to take place using minimum transmission power compared to the amount required at present.

However, due to circuit loss and noise, the photon state and quantum superposition state quickly breakdown. In order to realize quantum cryptography and quantum communications, technology that amplifies photon states and quantum superposition states while avoiding noise mixing is critical. However, with existing optical amplification technology, noise mixing cannot be fundamentally avoided, and so it was not possible to amplify optical signals while maintaining quantum-mechanical properties.

Quantum tele-amplification

Therefore, we recently developed technology called quantum tele-amplification. Using this technology, we can amplify and regenerate weak laser optical signals as large signals over to distant locations without any noise mixing.

First, the receiver prepares in advance a special state called a "quantum superposition state" where 0 and 1 waves of laser light exist concurrently (so-called Schrödinger's cat state). Furthermore, he adjusts the wave amplitude so that it is as large as possible. Next, the receiver separates the quantum superposition state with a split beam into two beams, B and C, and sends beam C to the sender. In the case of the quantum superposition state, a special correlation called a "quantum entanglement state" forms between the B and C beams after the split. This quantum entanglement state is one in which two states—"the state where beam B is a 0 wave, beam C a 1 wave" and "the state where beam B is a 1 wave, beam C a 0 wave"—exist concurrently, and beam C's observation result directly extends to beam B. In other words, if we observe beam C and learn it is a 0 wave, we can automatically determine that beam B is 1. Conversely, if we know beam C is a 1 wave, beam B is determined to be a 0 wave. Because quantum entanglement state is shared in advance between sender and receiver, the sender's input signal can be regenerated by the receiver's beam B without transmitting the input signal via an optical channel.

After the sender finishes combining beams C that arrived and input signal beam A with a beam splitter, he measures the two beams with a photon detector. The receiver can regenerate the amplified output signals without noise only in the case where photons are detected in beam A, but not in beam C (Figure 1).

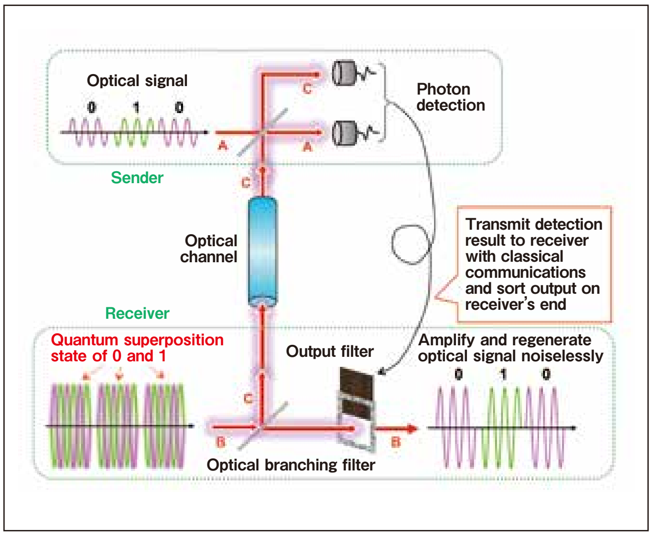
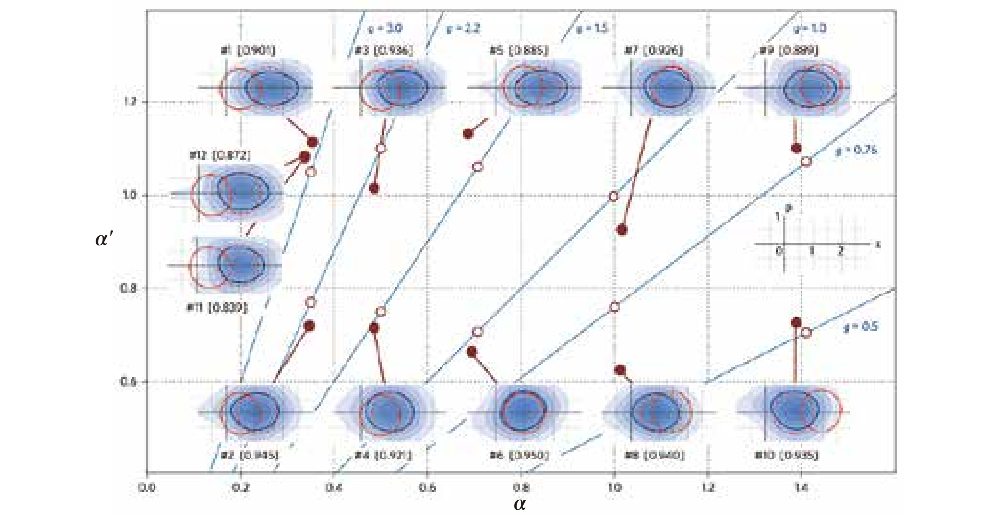


Figure 1　Quantum tele-amplification structure

In this method, the sender's signal disappears when the sender conducts photon detection without passing through an optical channel. Furthermore, even when looking at the photon detection result, we cannot know whether the signal we want to send was 0 or 1. Even so, the exact signal is regenerated in an amplified form by the receiver without noise.

With our achievement, this manipulation, called quantum teleportation, is supplemented with a new function that increases wave amplification without noise. What made this possible is the high-purity quantum superposition state generation/control



Horizontal axis is the input signal wave amplitude α, vertical axis is the output signal wave amplitude α' (=gα)

Figure 2 Quantum tele-amplification experimental result

technology developed at NICT. In the quantum information-communications research and development community, the technology to control photons one by one and generate/control quantum entanglement states composed of two photons has been developed and can be used at many research centers. However, generating/controlling quantum superposition states composed of many photons is still difficult, and can be achieved only by a limited number of research centers. This achievement is the first case in which a quantum superposition state was applied to a communication protocol.

Experimental result

Figure 2 summarizes the experimental result that was actually conducted. The horizontal axis is amplitude α of input signal waves and the vertical axis is amplitude α'(=gα) of output states. The blue line is the gain curve that shows how many times input amplification was increased and outputted. The white circles are the theoretical values and the red circles the experimental values. The blue contour distribution maps that show the state of each red circle represent the properties of output signal waves. In the world of quantum mechanics, decided amplification values are always swaying and cannot be accurately decided as light wave states cannot be completely determined (this is called the uncertainty principle). The distribution maps indicate the distribution of expected amplification values and the extent of their fluctuations. The blue and red lines within each distribution map indicate the representative contours for comparing input/output states. The solid red lines are actual input states, the dotted red lines are target output states, and blue solid lines are output states obtained from experiments. The numbers within each distribution map's [ ] are the overlapping conditions between target and actual output states, called fidelity. These numbers mean that the closer they are to 1, the quantum tele-amplification becomes more accurate.

Distribution maps #1–#10 are experimental data of cases with no optical channel energy loss. In all cases, high-accuracy tele-amplification is conducted with fidelity between 88–95%. #11 and #12 are experimental data of cases where channel loss is significant at 80%, but even in these cases, high fidelity over 84% is attained and quantum tele-amplification demonstrates its loss tolerance. In order to tele-amplify input amplitude α by g times, it is necessary to prepare a superposition state with the target output amplitude gα and roughly the same amplitude β in the receiver's end.

Future prospects

Quantum tele-amplification can be used for creating quantum computer gate functions that utilize optics and in-circuit signal amplification. In particular, if a light quantum photon is incorporated into a receiver, it can become a quantum decoder*2 that can extract maximum amount of data per photon. This achievement is expected to lead to breakthroughs in research aimed at extremely low-power, large-capacity quantum communications.

In the future, we will further downsize experimental systems using optical integration technology and apply this to extending quantum cryptography distance and quantum receiver research and development. Ultimately, we will carry this into development of quantum cryptography, quantum computer, and interface technology that allows system integration of quantum communication on optical infrastructure.

Glossary

***1 Photon**

According to quantum mechanics, light has both "wave" properties and "particle" properties. A particle of light, called a "photon," is the smallest unit to which light energy cannot be divided. For example, in a 1.5 micron wavelength commonly used in optical communications, one photon of energy is roughly 1/1019 joule, an extremely small value. A single photon is a state with only one photon within a pulse. Similarly, an n photon state means there are n number of photons within a pulse.

***2 Quantum decoder**

In communication systems, information such as sounds and images you wish to send are expressed in digits of digital symbols 0, 1 (so-called encoding), then transmitted and processed. When encoding, in order to counter errors that occur in transmission processes, information is deliberately expressed with additional digits of extra 0, 1's. For example, by repeating 3 digits like 0 to 000 and 1 to 111, transmission takes three times as long but transmission reliability is improved. In other words, there are cases where even when 000 is sent, different digits such as 001, 010, or 100 appear on the receiving end due to errors in the communication channels. However, if there are more than two 0's, it is possible to reduce final signal decision errors by evaluating that the original number was 000. Here, we examine the arrived signal and then decode to restore the original message. The decoding device for doing this is called a decoder.
A "quantum decoder" is a new decoder that incorporates quantum computation *3 into this decoding process. Conventional decoders first examine each signal pulse of the digits received and after decoding them into digits of 0, 1's, perform error correction processing with a computer. However, with a quantum decoder, before each signal pulse is examined, the received digits are first inputted into a quantum computer, processed, and then finally examined and decoded. Processing on quantum computers will allow access to larger volumes of information because error correction can be performed that is much more advanced than ever before. Latest theories support that extremely efficient low-power / high-capacity communication method is achieved by transmitting and encoding with laser optics, and receiving with quantum decoder. As a result, we will abolish classical communication theory limitations (Shannon limit) and eventually achieve high-capacity communication with transmitted power several orders of magnitude smaller than at present.

***3 Quantum computation**

In existing computers, only one value, "0" or "1," can be taken per bit. Due to this, when processing N bits of information, one must retrieve all 2N digits of bits one by one from digit 00 … 0, 00 … 1 to 11 … 1 2N times. However, with quantum computing, by using quantum bits which have "0" and "1" states concurrently, equivalent processing can be executed by preparing a state with all 2N bit digits overlapped and then calculating it only once. This enables the execution of massively parallel computing which is impossible even with current super computers.

Report on Interop Tokyo 2013

NICT participated in the Internet and digital media focused event, Interop Tokyo 2013 (June 12–14, Makuhari Messe).

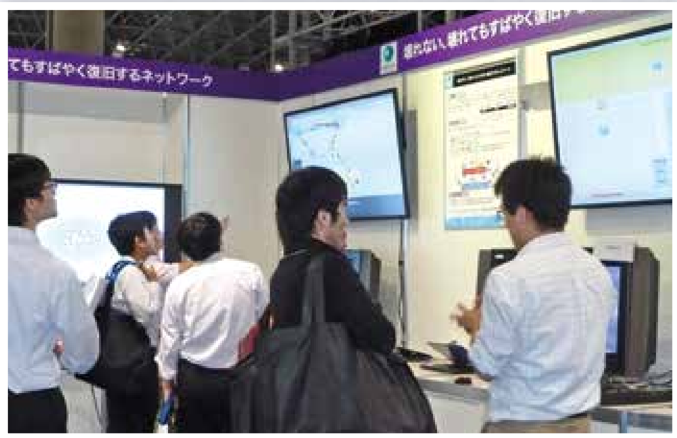
Under the theme of “New-Generation Networks for Realizing a Bright Future”, NICT presented the research achievements on new-generation network technology, testbed technology, and network security technology as shown below.

We received questions and opinions from interested visitors, which showed the high concern for network operations and security administration in the age of Clouds and Big Data. In addition, “NIRVANA Kai”, a cyber attack integrated analysis platform, and the “Virtualization-compliant WiFi network” which prioritizes the connectivity of important and urgent WiFi communications, received much attention, assisted by the press release right before the exhibition event.

We also obtained many impressions and questions such as “we would like to use this in our company” and “when will it be available for practical use?” The event was a valuable opportunity which encouraged us to pursue our research.

Exhibition Overview

〈New-generation network technology〉

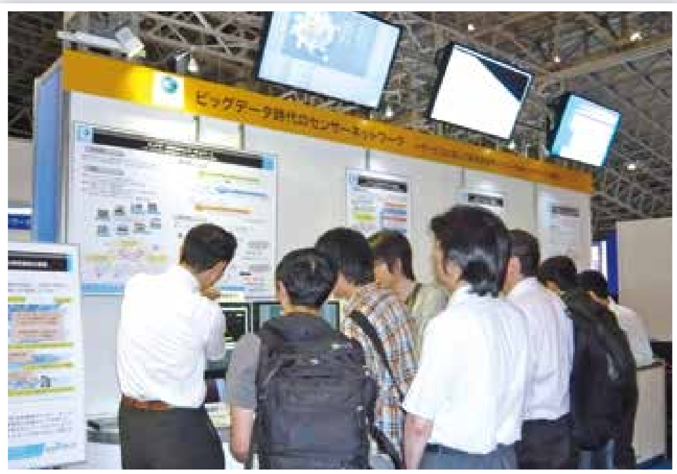


●Highly-available network

We had failure recovery live demonstrations. 1) Alternate route switching by HANA (Hierarchical Automatic Number Allocation) technology. 2) Seamless layer-3 handover by HIMALIS (Heterogeneity Inclusion and Mobility Adaptation through Locator ID Separation) technology.

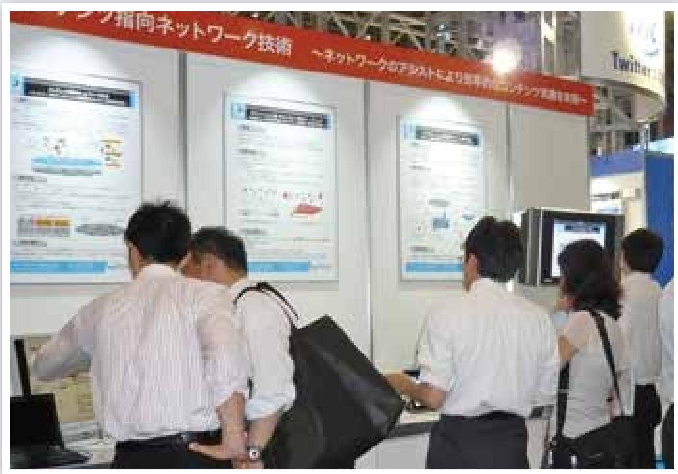
●Optical packet and circuit integrated network system

We exhibited network management system, automatic switching of packet link and circuit link, and high-speed packet-header processing equipment for optical packet and circuit integrated networks.



●Sensor network in the era of Big Data

We demonstrated element technologies—a sensor network infrastructure for utilizing Big Data based on a vast amount of sensor information—which enable on-demand construction of highly available networks in response to service requests and situational changes.



●Content-oriented network technology

We showed two types of demonstrations of content-oriented networking technologies—a content-size-based in-network cache mechanism to give faster response for obtaining contents, and an efficient content discovery and distribution mechanism from in-network cache.

NICT booth crowded with visitors

〈Testbed technology〉

●Wide area OpenFlow testbed RISE

We demonstrated the operations management system for wide area OpenFlow testbed RISE(Research Infrastructure large-Scale network Experiments), designed to provide researchers, developers, and operators large-scale and tailor-made environments for cutting edge SDN experiments.

●Data mobility service based on SDN

We held a demonstration in which data is automatically transferred to the nearest cloud by cooperating with SDN control technology such as OpenFlow and path provisioning, constructing secure paths, and changing VPN routing responding to network quality.

●Resilient ICT@StarBED^3

We created a very accurate and large-scale replication of the ICT environment for the test target area on StarBED. Then we damaged it based on a disaster scenario, and demonstrated the observation techniques of the impact on communication infrastructure and 'horizontal and vertical integration' of resilient ICT with remaining infrastructure.

〈Network security technology〉

●Network Incident analysis Center for Technical Emergency Response “nicter”

We demonstrated nicter, a cyber attack monitoring/analyzing/responding system designed to quickly respond against various attacks that occur in networks. We also showcased the platform “NIRVANA Kai” that allows integrative and visual analysis of communication situation and cyber attack alerts in organization networks.

●REGISTA (Risk Evaluation and Guidance on Information Security Technology Application)

We showed a demonstration of “REGISTA” which analyzes security risks hidden in networks and displays appropriate countermeasures and visualizations according to the security level a user requests.

Report on

The 3rd Information and Neural Networks Symposium

—Next-generation information communications leading the way in brain science—

The 3rd Information and Neural Networks Symposium, hosted by CiNet (the Center for Information and Neural Networks comprised of NICT, Osaka University, Advanced Telecommunications Research Institute International (ATR)), was held on June 10, 2013 at the Tokyo International Forum. The symposium is aimed at introducing the current state of next-generation information communications research outcomes from the integration of brain science and information-communications technology. This year, the forum was close to capacity with approximately 400 participants.

As guest greetings, KUBOTA Masayuki, Director-General for Policy Coordination, Minister's Secretariat, Ministry of Internal Affairs and Communications, and HISHIYAMA Yutaka, Deputy Director-General, Ministry of Education, Culture, Sports, Science and Technology, talked that Japan is now leading research on brain information communications and will continue to do so in the future by transcending government ministry boundaries and continuing to promote research in the field.

The special invited speaker, MIYASHITA Yasushi, Professor of Graduate School of Medicine, The University of Tokyo, talked about the neurological basis of individual and subjective cognition. There was a simple demonstration using video, which showed that even when looking at the same object, the perception differs among individuals. It resulted in a thought-provoking speech, leaving the audience to ponder on the essence of information communications.

In the special speech, IKEGAYA Yuji, Associate Professor in Graduate School of Pharmaceutical Sciences and CiNet Researcher, gave a talk in an easy to understand manner to non-specialist visitors and others on intriguing topics such as the fact that spontaneous activity that accounts for 80% of brain activity actually forms special patterns and that there's a possibility that mental illnesses will be cured by intervening on such areas of spontaneous activities. YANAGIDA Toshio, Center Director of CiNet, and researchers in four research areas also gave talks on the outline summary of CiNet and the current state of research. We received many feedbacks from participants such as "the speech session was beneficial with very rich content."

In the poster session, researchers stood around a total of 51 posters (12 for each area and 3 for the outline) where active information exchanges took place. Due to the limited time, participants who hoped to interact directly with researchers commented that they "wanted the poster session to run longer."

At the panel discussion, set with a theme of seeking the essential themes of each area, lively discussions ensued, coordinated by YANAGIDA. Various questions were posed from students majoring in physics, homemakers, and others, which indicated the high level of interest in this research field and anticipation for research achievements.

We hope to continue sharing CiNet activities with the general public through symposiums and other methods in the future.

Special speech by IKEGAYA Yuji

The view of panel discussion

Awards

Recipients ● **Eloy Gonzales** / Researcher, Information Services Platform Laboratory, Universal Communication Research Institute
Bun Theang Ong / Researcher, Information Services Platform Laboratory, Universal Communication Research Institute
ZETTSU Koji / Director of Information Services Platform Laboratory, Universal Communication Research Institute

◎Award Date: October 26, 2012

◎Name of Award: **Best Paper Award**

◎Details:

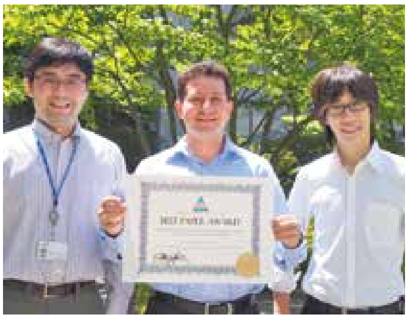
The evaluation was based on the reviews of the original submission, the camera-ready version, and the presentation during "the Second International Conference on Advances in Information Mining and Management" conference.

◎Awarding Organization:

International Academy, Research, and Industry Association

◎Comment from the Recipients:

In this paper, we propose a method that enables extraction of optimal association rules from even uncertain data sets using evolutionary algorithms. Our proposed method was recognized for decreasing unnecessary processing by devising automatic termination criterion of evolutionary algorithms and reducing computational resources without loss of reliability of calculated results, leading to increased efficiency. Our research achievement is also being applied to association search technology (Cross-DB Search) which searches cross data in various fields.



From left: ZETTSU Koji, Eloy Gonzales, Bun Theang Ong

Recipient ● **EMURA Keita** / Researcher, Security Architecture Laboratory, Network Security Research Institute

Co-recipients:
HANAOKA Goichiro, National Institute of Advanced Industrial Science and Technology
MATSUDA Takahiro, National Institute of Advanced Industrial Science and Technology
OHTAKE Go, Japan Broadcasting Corporation
YAMADA Shota, The University of Tokyo

◎Award Date: January 23, 2013

◎Name of Award: **Innovation Paper Award**

◎Details:

This paper was selected for the innovation paper prize which aims at encouraging new research and technological development.

◎Awarding Organization:

Technical Committee on Information Security (ISEC), The Institute of Electronics, Information and Communication Engineers (IEICE)

◎Comment from the Recipient:

We are so pleased to be the first recipient of the innovation paper award which was newly established in 2012 at Japan's largest information security conference, SCIS.

This paper proposed a new cryptographic primitive "Keyed-Homomorphic Public Key Encryption" in order to achieve both homomorphic property and ideal-security level so called CCA security, simultaneously.

Recipient ● **TAZAKI Hajime** / Senior Researcher, Network Architecture Laboratory, Photonic Network Research Institute

Co-recipients: Frédéric Urbani (INRIA, France)
Thierry Turletti (INRIA, France)

◎Award Date: March 5, 2013

◎Name of Award: **Best Paper Award**

◎Details:

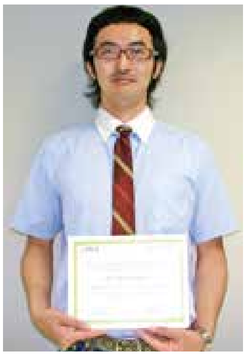
The submitted paper, "DCE Cradle: Simulate Network Protocols with Real Stacks for Better Realism," was recognized as an excellent paper for its quality, distinctiveness, and significance for network simulator ns-3.

◎Awarding Organization:

Technical Program Committee for the Workshop on ns-3

◎Comment from the Recipient:

Network simulation is a useful tool for verifying network protocols along with a wide variety of parameters, but at the same time, it is difficult for the experimentation results to authentically reproduce actual network behavior. In order to resolve this issue, we proposed and implemented a system that can evaluate the network protocol within a simulation combined with Linux kernel, a real-world software, and presented it in this award-winning paper. We sincerely thank everyone who helped assist us in this research.



Recipients ● **SUMITA Eiichiro** / Director of Multilingual Translation Laboratory, Universal Communication Research Institute
HORI Chiori / Director of Spoken Language Communication Laboratory, Universal Communication Research Institute
Paul Richard Dixon / Researcher, Spoken Language Communication Laboratory, Universal Communication Research Institute
Andrew Michael Finch / Senior Researcher, Multilingual Translation Laboratory, Universal Communication Research Institute
Michael Paul / Senior Researcher, Multilingual Translation Laboratory, Universal Communication Research Institute

◎Award Date: March 15, 2013

◎Name of Award:

58th Maejima Hisoka Award

◎Details:

Speech translation technology research and development

◎Awarding Organization:

Tsushinbunka Association

◎Comment from the Recipients:

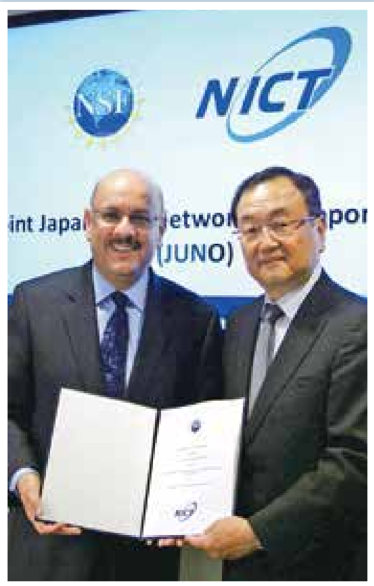
We were recognized and awarded for establishing an international standard for speech translation protocols in ITU-T and creating a foundation for multilingualization, organizing U-STAR and 26 institutions in 23 countries, initiating global experiments with VoiceTra4U-M, a system that covers approximately 95% of the world's population, and actively providing licenses to the private sector. The fact that there were award winners with foreign nationals for the first time in this award's history also attracted much attention. We are grateful to the many NICT people whose cooperation made this possible.

From left: Michael Paul, HORI Chiori, SUMITA Eiichiro, Andrew Michael Finch, Paul Richard Dixon

MOU Concluded between NICT and NSF

On May 29, 2013 U.S. time, NICT and the National Science Foundation (NSF) concluded an MOU (Memorandum of Understanding) at the NSF Headquarters (Arlington, Virginia, USA), agreeing to work together towards Japan-US collaborative research for realizing new-generation networks.

Even before this MOU conclusion, NICT and the Division of Computer & Network Systems, Directorate for Computer & Information Science & Engineering, NSF, have been collaborating on mainly new-generation networks / future Internet research. As a continuation of their past collaboration, both the US and Japanese government confirmed their cooperation in the area of new-generation networks (NWGN) / future Internet research and development on March 23, 2012 at the third Director General-level meeting of the U.S.-Japan Policy Cooperation Dialogue on the Internet Economy. After this, researchers from the two countries held discussions and reached a common understanding which was that cooperation in the advancement of research is desirable in the following three areas: (1) optical networks, (2) mobile computing, and (3) network design and modeling. In order to support collaborative research in these three areas, NICT and NSF have decided to cooperate with each other. With this agreement, NICT and NSF plan to promote collaboration between Japanese and American researchers for research in networking technology and systems enabling new-generation networks / future Internet.



[Left] Farnam Jahanian, Assistant Director for Computer and Information Science and Engineering, NSF, and IMASE Makoto, Vice President, NICT, after the MOU conclusion
[Right] NICT and NSF affiliates after the MOU conclusion

Information for Readers

The next issue will feature WiFi communications that can preferentially connect important and urgent communications even during periods of congestion, as well as an application for portable devices that assists in communication with hearing-impaired people, and more.

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