NMIJ Newsletter
No.5, May 2017

Greetings from New Director General

Dr. Takashi Usuda
Director General,
NMIJ/AIST

First of all, I would like to express deep appreciation on behalf of NMIJ to all NMIs, BIPM, BIML, RMOs, and related institutes/organizations for the longstanding supports and collaborations.

The NMIJ has made major progress in the past 7 years under the leadership of the former Director General, Dr. Yukinobu Miki. I am delighted to have the opportunity to succeed to his position and lead NMIJ. I am also keenly aware of the responsibility. I will try my best to develop NMIJ under my new role.

Nationally, NMIJ has a crucial role in supporting quality, efficiency and productivity in manufacturing, health, energy and environment. Needless to say, NMIJ is also expected to contribute to international metrology communities in terms of the redefinition of the SI, streamlining the CIPM-MRA, introducing OIML-MAA, etc. It is highly expected to support emerging NMIs as well.

Based on the awareness for these important missions of NMIJ, I would like to move forward with the key research activities and the bilateral/multi-lateral collaborations, aiming at the contribution to the international society.

Finally, I would like to express again my sincere thanks to all of you and would like to ask your cooperations. I look forward to working closely and sharing many common objectives with you to maintain our mutually beneficial relationship.

Biography

Director General, NMIJ/AIST, April 2017 –
President of CCAUV, November 2014 –
CIPM Member, July 2012 –
Deputy Director General, NMIJ/AIST, April 2015 – March 2017
Director of Metrology Management Center of NMIJ, 2012 – 2015
Visiting Scientist at the BIPM, 2010 – 2011
Senior Planning Director, Planning Headquarters, AIST, 2008 – 2010
Principal Research Scientist, NMIJ/AIST, 2008, 2012
Leader of Vibration and Hardness Section, NMIJ/AIST, 2003 – 2008
Senior Researcher, Vibration and Hardness Section, NMIJ/AIST, 2001 – 2003
Invited Researcher at the CNRS, 2000 – 2001
Planning Officer, Ministry of International Trade and Industry (MITI), 1999 – 2000
Invited Researcher at the PTB, 1998 – 1999
Senior Researcher, NRLM, 1996 – 2001
Researcher, National Research Laboratory of Metrology (NRLM), 1990 – 1996

NMIJ New Organization Chart

NMIJ was reorganized in April 2017. Public Relations Office and International Cooperation Office moved to Center for Quality Management of Metrology.

Greetings from Director of RIPM

Dr. Yasuhiro Nakamura
Director of RIPM

At the Research Institute for Physical Measurement (RIPM) under NMIJ, a lot of scientists and experts from the field of physics, material science and electrical engineering have gathered and are doing cutting edge research on precision physical measurements, physical property of materials and quantum devices, and are developing their applications to novel sensing technologies to be used in the field of electronics, energy, environment, biotechnology and so on.

We have also made contributions to development of metrology by promoting several research projects, such as the redefinition of second by the optical lattice clock, the precise measurement of Boltzmann constant and the challenge to the quantum metrology triangle by single electron device.

On the other hand, we have played important roles in establishment, maintenance and dissemination of the national physical standards in the areas of electricity, time and frequency, temperature, and photometry and radiometry. Various calibration services related to these physical quantities are provided with high accuracy to industry.

I hope that our research works and calibration services would contribute to development of technology and innovation in industry.

Introduction of RIPM

The Research Institute for Physical Measurement has totally about 70 research scientists and 30 technical staffs, and is divided into twelve research groups. Recent research topics and activities of each group are introduced as below.

■ Time Standards Group

The research and development on optical lattice clocks are conducted with techniques such as laser manipulation of ultra-cold atoms and stabilization of lasers for contributing to the redefinition of the second. UTC(NMIJ) (one of the national time scale in Japan) is also continuously maintained as an ultra-precise microwave frequency standard remotely available via GPS satellites.

■ Quantum Electrical Standards Group

Quantum electrical precision measurements using quantum effects, the Josephson effect, the quantum Hall effect and the single electron tunneling effect are the main topics of the group. They include high speed control of single electrons and application of it for quantum metrology triangle experiments, a quantum current standard and charge sensors. Group's research interests lie in the area of nanoscience, condensed matter physics and their applications to metrology and sensors. The national voltage standard and the national resistance standard have been developed and maintained, and calibration services by them have been also provided by the group.

■ Electromagnetic Measurement Group

The measurement techniques and metrological standards in the wide frequency band from kHz to THz are researched and developed. As the results, high accuracy measurements with a vector network analyzer (VNA) have been realized. The focused research projects are measurement techniques of electromagnetic wave characteristics such as dielectric constant of materials and planar circuits. In addition, new electromagnetic sensing techniques are being developed.

■ Frequency Measurement Group

Optical frequency combs, in particular, their generation, control, and applications for precise measurements have been studied. For example, novel technologies of controlling comb and innovative gas spectroscopy for environmental monitoring have been investigated. In addition, our combs have already been used as the standard of length in Japan by combining with the frequency standard and used for stabilizing laser frequency and narrowing spectral linewidth of lasers in optical lattice clocks.

■ Applied Electrical Standards Group

Precise electrical measurements are very useful to guarantee the quality of products as well as obtain new knowledges. The precise impedance spectroscopy method allows us to evaluate the lifetime prediction of lithium-ion batteries (LIBs) and super-capacitors. A new method using our Thomson-coefficient integration technique is beneficial to determine an absolute Seebeck coefficient. In addition, the national standards for AC/DC transfer, AC voltage, inductance, capacitance, and current transformers have been developed and maintained.

■ Radio-Frequency Standards Group

Novel RF measurement technologies are developed in a broadband frequency range. Our research is focused on promising areas including terahertz measurement technology, quantum-based precision RF power measurement and chip scale atomic clock using a small cesium gas cell. Calibration services for RF industry ranging from mobile communications to materials processing are also provided.

■ Electromagnetic Fields Standards Group

Recent research topics are electromagnetic field (EM-field) measurement using mobile robot, digital comb-generator for sub-30 MHz EMI (Electromagnetic Interference) test system and RoF (Radio over fiber) technologies for antenna measurement. Calibration services for antennas in the frequency range from 9 kHz to 110 GHz are available. Calibration services for magnetic and electric field sensor and RCS (Radar cross section) of corner reflector in W-band (75 GHz - 110 GHz) are also available.

■ Frontier Thermometry Research Group

Temperature calibration systems and thermodynamic temperature measurement are extensively studied. Two different types of temperature calibration systems have been developed. One of the systems based on nuclear magnetic refrigerator operates in the temperature range from 650 mK down to below 1 mK. The other system using Joule-Thomson effect of ^{3}He gas covers from 650 mK to 20 K with stability better than 0.1 mK. A temperature scale based on vapor pressure of ^{3}He gas is also realized. Expertise in cryogenic technology is provided to interdisciplinary fields such as bioscience and material science. Besides, measurement of the Boltzmann constant is going on with Johnson noise thermometer using an integrated quantum voltage noise source.

■ Photometry and Radiometry Research Group

Optical sensor characterization, absolute spectroradiometry and optical properties of materials are studied with emphasis on the development of advanced measurement techniques and their application. Current focused topics are detector-based UV-LED radiometry, optical non-linearity characterization of detectors, total spectral radiant flux measurement for forward-emitting sources and gonioreflectometer-based BRDF characterization of materials. Another indispensable task is the development, improvement and dissemination of national scales for the candela (cd) and other primary quantities in the field of photometry and radiometry.

■ Thermometry Research Group

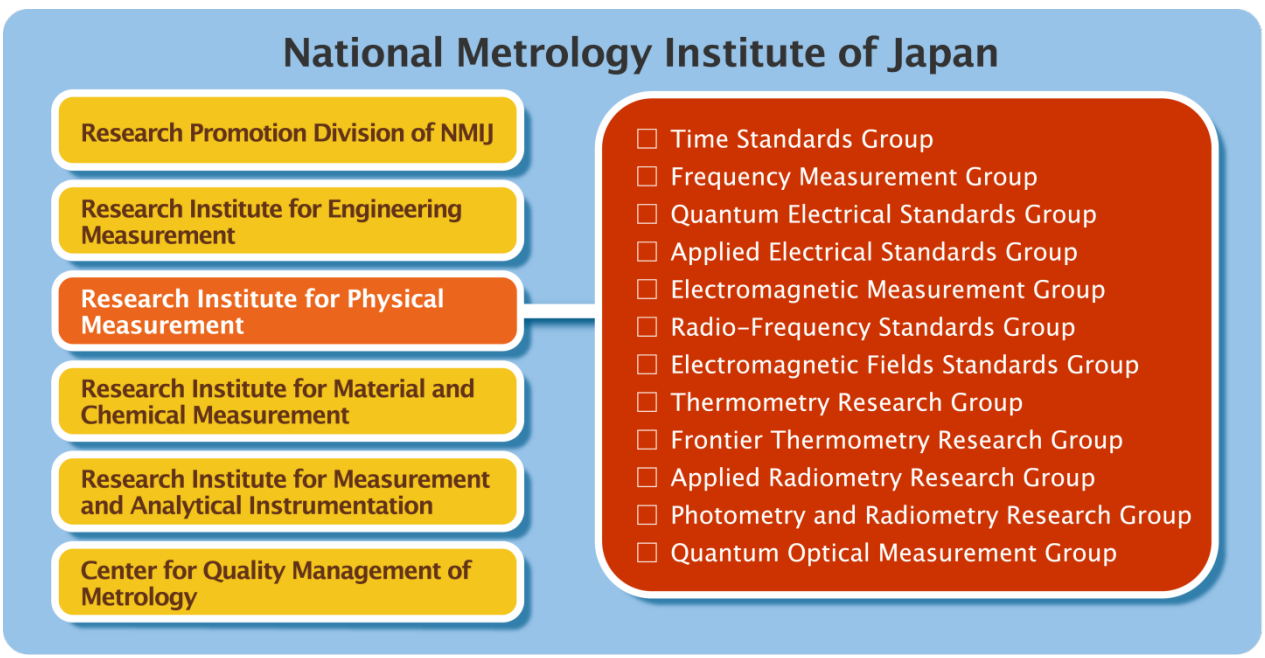
New sensing elements, such as resistance thermometers and thermocouples, and new techniques for temperature measurement are developed and evaluated in the temperature range from -260℃ to near 2000℃ based on national standards of temperature. We also develop an acoustic gas thermometry (AGT) and a constant volume gas thermometry to determine thermodynamic temperature. AGT is also considered for the precise measurement of Boltzmann constant to contribute the redefinition of Kelvin.

■ Applied Radiometry Research Group

Advanced radiometry and that applications are studied on the bases of absolute measurement. On-going research and development topics are radiometric measurement methods optimized for the light sources based on newer technology such as LED, ultra-low reflectance optical absorbers based on micro-structured surfaces, radiometric evaluation methods of the remote sensing sensors and radiation thermometry utilizable in industrial applications.

■ Quantum Optical Measurement Group

Quantum optical measurement group has been researching on technologies with single photon detection/generation and its radiometry. A photon is the smallest unit of light, which gives the fundamental measurement limits. The use of the limit will extend new applications such as highly sensitive photon imaging systems, single photon spectroscopy, and secure telecommunication in the fields of biotechnology and quantum information. To meet these requirements, quantum devices such as high detection efficiency superconducting photon detectors and their readout circuit, highly pure quantum photon sources are being developed in the group.



NMIJ activities (October 2016 – April 2017)

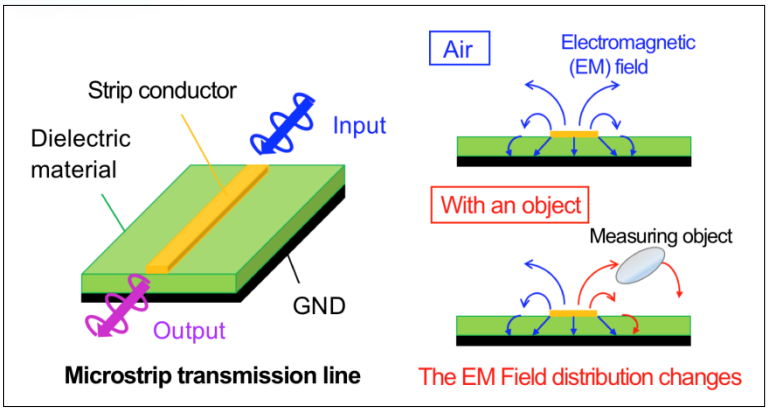
Research topics

Development of technique for easily measuring moisture content of agricultural products using an electromagnetic wave

Seitaro Kon and Masahiro Horibe

Up to this point, the moisture content of agricultural products is determined by extracting a sample from a large amount of agricultural products in a place such as a collection point, and measuring the electrical resistance of ground samples or measuring the difference in weight before and after drying samples. However, sampling and measurement spend time and effort. For this reason, there has been an increased need to develop a method capable of performing quality inspections in a short period of time, of all agricultural products to be shipped, and further, capable of inspecting the final packed products.

Therefore, a method capable of measuring the moisture content of agricultural products within one second using an electromagnetic wave has been developed. An object can be measured regardless of its size or shape, and even if it is packed or boxed.



Principle of moisture content measurement using a microstrip line

Moisture content is measured utilizing the fact that when bringing the object being measured close to a microstrip line, the electromagnetic field distribution (amplitude and phase) changes.

In this method, agricultural products on a conveyer belt are irradiated ten times using an electromagnetic wave with a frequency of several GHz and then signal analysis of the transmitted wave is performed. Since the data is acquired within one second, all products can be inspected in close to real time. Agricultural products can also be measured after being boxed, and therefore this method is expected to facilitate sorting and quality control at the production site.

More detail:
http://www.aist.go.jp/aist_e/list/latest_research/2017/20170414/en20170414.html

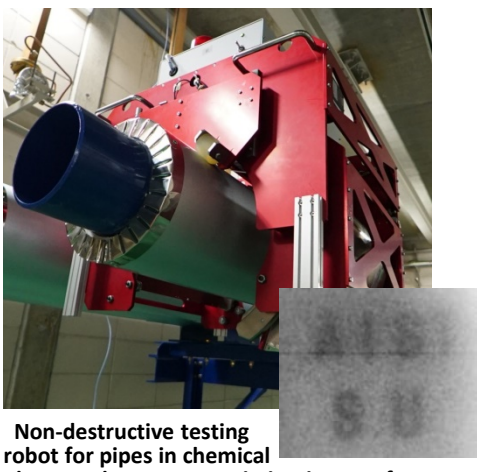
Compact and high-energy X-ray non-destructive testing system for infrastructure maintenance robots

Ryoichi Suzuki, Hidetoshi Kato and Takeshi Fujiwara

X-ray transmission technique is one of the non-destructive testing methods for evaluating aged infrastructures. In order to apply compact X-ray system to automated non-destructive testing robots for infrastructure maintenance, NMIJ has developed high energy compact X-ray sources of 200 kV tube voltage and X-ray detectors.

The X-ray source uses a carbon nano structure based cold cathode and can be operated by portable batteries. The X-ray detectors have been optimized for high-energy X-rays. These X-ray sources and detectors can be installed in a non-destructive testing robot for pipes in chemical plants.

Performance test of X-ray system confirmed that X-ray transmission images of 50 mm thick steel can be obtained with a single shot X-ray pulse of 0.1 second, and images of 70 mm thick steel can be obtained from the sum of 18 X-ray shots. This performance enables us to perform thickness measurement of steel pipes which is covered by thermal insulating materials.



Non-destructive testing robot for pipes in chemical plants and X-ray transmission image of 70 mm thick steel

More detail (in Japanese):
http://www.aist.go.jp/aist_j/press_release/pr2016/pr20161221/pr20161221.html

Featured events

The 14th NMIJ-KRISS Summit

The NMIJ hosted the 14th NMIJ-KIRSS Summit on 3rd October in Tsukuba, Japan and welcomed seven delegates from the Korea Research Institute of Standards and Science (KRISS) including Prof. Dr. Dongil Kwon, President of KRISS. The parties reviewed the progress of their continuous research cooperation called "Package" and agreed to add two new areas of research cooperation to it. The Summit also provided an opportunity for KRISS delegates to visit NMIJ's laboratories of time standards, vibration and hardness standards, and ionizing radiation standards.

MEDEA Workshop on laser interferometers for length measurement

The MEDEA (Metrology - Enabling Developing Economies in Asia) project is organized by APMP, APLMF and PTB to raise the metrology level in Asia. This workshop was one of the training courses of MEDEA project. The eligible applicants of this workshop were the experts on length metrology in national research institutes of metrology and/or the same level authorities in OECD countries in Asia. The purpose of this workshop was to support participants who provide high-level length metrology system for their economies with using laser interferometers.

This workshop was held at NMIJ, Tsukuba from 3rd to 7th October 2016. Fifteen participants from ten countries took part in this training course. Eight researchers from NMIJ participated in this workshop as trainers. The content of the training started with basic knowledge of optics, and led to high-level laser interferometers. The daily schedule was set lectures in the mornings and conducting experiments related to the lectures in the afternoons. According to the post-training survey by PTB to the participants, the degree of satisfaction of this workshop was very high. We believe the participants could learn a lot about laser interferometers. Good relationships between participants' NMIs and NMIJ were also built up.

This year, we will provide the follow-up training at several institutes of the participants.

Execution of MoU between NMIJ and NMIA

The NMIJ and the National Measurement Institute, Australia (NMIA) entered into the Memorandum of Understanding (MoU) on 10th October in Sydney, Australia. It intended to re-establish the previous MoU which was effective until 2012. It will bring about enhanced cooperation in the fields of metrology between the two institutions.

NMIJ took over APMP secretariat from NMIA

Asia Pacific Metrology Programme (APMP) General Assembly (GA) and related meetings were held in Da Nang, Vietnam from 9th to 19th November 2016. Dr. Peter Fisk, NMIA, has successfully completed his term as the APMP Chair and Dr. Toshiyuki Takatsuji, Director for Research Institute of Engineering Measurement, NMIJ started his term. Simultaneously, NMIJ succeeded secretariat from NMIA. In the GA the election of new Executive Committee member and the endorsement of new Technical Committee (TC) Chairs were carried out. Emirates Metrology Institute (EMI) from United Arab Emirates signed on Memorandum of Understanding and became an associate member of APMP.

The next APMP official meeting is the Mid-Year Meeting that will be held in Malacca, Malaysia, hosted by the National Metrology Institute of Malaysia in May. The GA and related meetings will be held in New Delhi, India, hosted by National Physical Laboratory of India (NPLI) from 26th November to 1st December 2017.

The 23rd APLMF Meeting held in Tokyo

Asia Pacific Legal Metrology Forum (APLMF) is a regional metrology organization attended by the legal-metrology authorities in the Pacific Rim. The 23rd APLMF Meeting and Working Group Meetings were held at the AIST Tokyo Waterfront from 23rd to 25th November 2016. The meetings were hosted jointly by NMIJ and Ministry of Economy, Trade and Industry (METI). The attendees were: 45 delegates from the 17 member economies, four guests and two representatives of international/regional organizations.

It was a memorable meeting chaired by the new president Mr. Stephen O'Brien (New Zealand) for the first time. During the meetings, a number of topics including annual reports from APLMF President and Secretariat, the seven APLMF Working Groups, and international/regional metrology organizations were addressed. The participated economies provided a brief report summarizing metrological systems and recent topics in each economy. In addition, many fruitful discussions took place on strategies and future plans of APLMF under the leadership of President.

The 24th APLMF meetings will be held in Siem Reap in Cambodia in October 2017.

Execution of LoI with TISTR

The NMIJ signed the Letter of Intent (LoI) for scientific and technological research cooperation with Thailand Institute of Scientific and Technological Research (TISTR) at Bangpoo, Thailand, on 28th February 2017. This LoI is intended to promote future cooperation on chemical metrology and other related fields under the framework of the Memorandum of Understanding (MoU) signed between TISTR and NMIJ.

Dr. Usuda handed over the Presidency of the CCPR

Dr. Takashi Usuda, CIPM member has handed over the Presidency of the Consultative Committee for Photometry and Radiometry (CCPR) to Dr. Maria Luisa Rastello, INRIM (Italy). He served as the President of CCPR from 2013 to 2016. The handover of responsibilities took place at a meeting to discuss CCPR presidential activities which was held in Turin (Italy) on 17th March 2017. The meeting was also attended by Dr. Joële Viallon, Executive Secretary of the CCPR. Dr. Usuda will continue as President of the Consultative Committee for Acoustics, Ultrasound and Vibration (CCAUV). Dr. Rastello was provisionally elected to the CIPM on 7th December 2016.

Director of NPL visits NMIJ

Dr. Peter Thompson, Director, and Dr. Kamal Hossain, International Director of National Physical Institute (NPL), UK's National Measurement Institute, visited NMIJ on 21st March 2017. After the introductory talk and discussions with Dr. Yukinobu Miki, Director General, Dr. Takashi Usuda, Deputy Director General, and Dr. Akiharu Hioki, Manager of International Cooperation Office (ICO), they visited the atomic-clock laboratory of the Time Standards Group, and other research laboratories of NMIJ.

Renewal of MoU between CENAM and NMIJ

The Memorandum of Understanding (MoU) between NMIJ and National Metrology Center (CENAM), the United Mexican States, was renewed on 30th March 2017. The objective of this Memorandum is to strengthen the relationship between CENAM and NMIJ and promote the cooperative research activities in the fields of reference materials and material measurements.

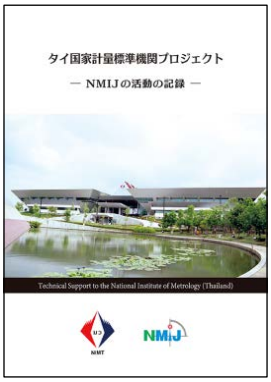
Director General of LNE visits NMIJ

Mr. Thomas Grenon, Director General and Mrs. Maguelonne Chambon, R&D Director of the Laboratoire National de Métrologie et d'Essais (LNE, France) visited NMIJ on 27th and 28th April 2017. After the discussions with Dr. Takashi Usuda, Director General of NMIJ and greeting to Dr. Yukinobu Miki, Senior Vice-President of AIST, they visited several research laboratories, standards laboratories and Metrology Training Center.

A booklet on "NIMT Project"

The NMIJ has issued a booklet (in Japanese) of the memories on technical cooperation project for the establishment of the National Metrology Institute of Thailand (so called "NIMT Project").

This large-scale project was completed after around 10 years of long period, from 1999 to 2008. In the same period of time, NMIJ was inaugurated, unifying all Japanese metrology standards. It became a good chance and experience for NMIJ to provide technical cooperation to NIMT. This booklet is mainly created from a series of activities and cooperation provided by NMIJ in chronological order, and also included a message from Mr. Prayoon, who is deeply involved to launch this project and has led NIMT as Director for a long period.



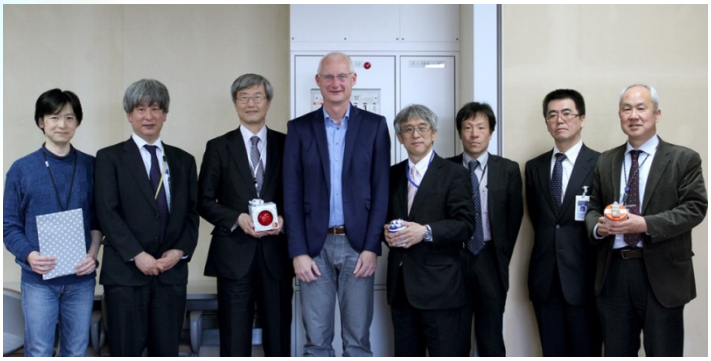
Peer review and international comparisons

The NMIJ dispatches peer reviewers to other NMIs on their requests (if available). In the recent half year, four researchers from the NMIJ visited two NMIs as on-site peer reviewers. Also, the NMIJ has participated in the following international comparisons within this period.

NMIJ Participants	KCDB Code	Field	Title	Pilot Lab
Dr. A. Widarta	CCEM.RF-K26	Radio Frequencies	Attenuation at 18 GHz, 26.5 GHz and 40 GHz using a step attenuator	NMIJ
Dr. K. Kinoshita	CCPR-K2.b.2016	Spectral Responsivity, 300 nm to 1000 nm	Comparison of spectral responsivity in A/W using Silicon trap detectors and Silicon photodiodes	KRISS
Dr. N. Aoki, Dr. T. Shimosaka	CCQM-K120.a & .b	Gas analysis, CO_2 in air	Comparability study of laboratories' preparation capabilities for Carbon Dioxide in Air Standards	BIPM, NIST
Mr. T.Yamazaki	CCQM-P150.b	Organic chemistry	Data acquisition and process in qNMR method with a practical sample	NMIJ
Dr. T. Hayashi, Mr. K. Ueda, Mr. H. Maejima	APMP.M.F-S3	Force, 1 kN	Supplementary comparison for 1 kN force	NMIJ
Dr. H. Kajikawa, Dr. T. Kobata	APMP.M.P-K7.3	Hydraulic gauge Pressure: 10 MPa to 100 MPa	Comparison of pressure measurements in oil	NIMT and NMIJ
Dr. T. Hayashi, Mr. K. Ueda, Mr. H. Maejima	APMP.M.F-S2	Force, 10–100 kN	Supplementary comparison for 10–100 kN force	NMIJ
Mr. R. Kizu	NANO6	Length, linewidth 30 nm to 250 nm	Preliminary International Comparison on Nanometrology according to the Rules of the CCL Supplementary Comparison. Nano6: AFM Linewidth Standards	NIST

Visitors

Many foreign guests visited NMIJ for technical discussions and a series of training. Ongoing and future collaborations were discussed with the guests listed below.



Guest from NMi, Netherlands

Name	Affiliation	Visiting Date	Visiting Topic
Dr. V. Fernicola	INRIM, Italy	Oct. 07	Technical visit to Gas and Humidity Standards Group
Dr. D. Kang	KRISS, Korea	Oct. 15 - 20	Discussion on the collaboration based on invitation program supported by JSPS
Prof. M. Ortolano, Ms. M. Marzano	Politecnico di Torino, Italy	Feb. 13 - Mar. 17	Design and fabrication of quantized Hall resistance array
Dr. R. Kramer	PTB, Germany	Mar. 06	Talk on the primary and secondary standards of PTB for gas flows and the future plan. Discussion on the future plan of inter-comparison for hydrogen flowrate.
Mr. Hafid	RCM-LIPI, Indonesia	Feb. 06 - 17	Metrological cooperation and a bilateral comparison of force
Dr. Q. Sun, Mr. H. Hu	NIM, China	Feb. 14 - 16	Cooperation on shock calibration technology between NIM and NMIJ
Dr. J. G. Hartnett	The University of Adelaide, Australia	Mar. 1 - Apr. 29	JSPS Invitation Fellowship for Research in Japan (Short-term)
Dr. P. Thompson, Dr. K. Hossain	NPL, UK	Mar. 21	Possible cooperation between NMIJ and NPL
Mr. C. Oosterman	NMi, Netherlands	Mar. 24	Technical visit to facilities related to legal metrology
Mr. T. Grenon, Ms. M. Chambon	LNE, France	Apr. 27 - 28	Possible cooperation between NMIJ and LNE

Selected research reports

1) N. Furuichi, L. Cordova, T. Lederer, Y. Terao, "Comparison of high-temperature and high-Reynolds-number water flows between PTB and NMIJ", Flow Meas. Instrum, **52**, 157-162, 2016.

2) A. Nishino, K. Ueda, Kenichi Fujii, "Design of a new torque standard machine based on a torque generation method using electromagnetic force", Measurement Science and Technology, **28**, 25005, 2016.

3) Y. Bitou, T. Kobayashi, F.-L. Hong, "Compact and inexpensive iodine-stabilized diode laser system with an output at 531 nm for gauge block interferometers", Precision Engineering, **47**, 528- 531, 2017.

4) T. Hayashi, K. Ueda, "Remaining differences among precision strain-gauge amplifiers for force transducers after compensation with reference to a common bridge calibration unit", Measurement, **95**, 260-265, 2017.

5) H. Iizumi, H. Kajikawa, T. Kobata, "A high gas pressure calibration system using a liquid-lubricated pressure balance", Measurement, **102**, 106-111, 2017.

6) N.-H. Kaneko, T. Oe, T. Abe, M. Kumagai, M. Zama, "Development of 1 Ω and 10 Ω metal-foil standard resistors", IEEE Trans. Inst. Meas., Early Access Article, 2016.

7) A. Domae, T. Oe, S. Kiryu, N. Kaneko, "Experimental demonstration of current dependence evaluation of voltage divider based on quantized Hall resistance voltage divider", IEEE Trans. Inst. Meas., Early Access Article, 2017.

8) J. V. Widiatmo, K. Harada, K. Yamazawa, "Characterization of high-temperature platinum resistance thermometers at silver point", Int. J. Thermophys, **38**, 43, 2017.

9) S. Shibayama, S. Fujii, K. Inagaki, T. Yamazaki, A. Takatsu, "Formic acid hydrolysis/liquid chromatography isotope dilution mass spectrometry: An accurate method for large DNA quantification", J. Chromatogr. A, **1468**, 109-115, 2016.

10) Y. Sakaguchi, T. Kinumi, A. Takatsu, "Quantification of peptides using N-terminal isotope coding and C-terminal derivatization for sensitive analysis by micro liquid chromatography-tandem mass spectrometry", J. Mass Spectrom., **51**, 1111-1119, 2016.

11) K. Hashiguchi, H. Abe, "Measurement error in frequency measured using wavelength meter due to residual moisture in interferometer and a simple method to avoid it", Measurement Science and Technology, **27**, 115004, 2016.

12) M. Amano, H. Abe, "Gas dilution system using critical flow Venturi nozzles for generating primary trace-moisture standards in multiple gas species", Measurement Science and Technology, **28**, 025007, 2017.

13) A. Wada, N. Nonose, M. Ohata, T. Miura, "Determination of ultra-trace metal impurities in high-purity cadmium using inductively coupled plasma mass spectrometry after matrix separation with anion exchange resin", Analytical Sciences, **33**, 357-364, 2017.

14) T. Yamazaki, S. Nakamura and T. Saito, "Optimization of sample preparation for accurate results in quantitative NMR spectroscopy", Metrologia, **54**, 224-228, 2017.

15) T. Matsumoto, A. Masuda, H. Harano, Y. Shikaze, Y. Tanimura, H. Seito, S. Kurashima, S. Nishino, H. Yoshitomi, J. Nishiyama, M. Hagiwara, Y. Unno, M. Yoshizawa, "Development of the high-energy neutron fluence rate standard field in Japan with a peak energy of 45 MeV using the Li(p, n)Be reaction at TIARA", J. Nucl. Sci. Technol., **54**, 529-538, 2017.

16) A. Masuda, T. Matsumoto, Y. Iwamoto, M. Hagiwara, D. Satoh, T. Sato, H. Iwase, H. Yashima, Y. Nakane, J. Nishiyama, T. Shima, A. Tamii, K. Hatanaka, H. Harano, T. Nakamura, "Applicability of the two-angle differential method to response measurement of neutron-sensitive devices at the RCNP high-energy neutron facility", Nucl. Instrum. Methods Phys. Res. A, **849**, 94-101, 2017.

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