2015 URSI-Japan Radio Science Meeting (URSI-JRSM 2015)

Tokyo Institute of Technology, Tokyo, Japan, September 3-4, 2015

Program and Abstracts Book

Sponsored by:
- The Institute of Electronics, Information and Communication Engineers (IEICE)

Technically supported by:
- International Union of Radio Science (URSI)

In cooperation with:
- Japan Geoscience Union
- Science Council of Japan
- The Astronomical Society of Japan
- The Institute of Electrical Engineers of Japan
- The Laser Society of Japan
- The Remote Sensing Society of Japan

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Message from URSI-JRSM 2015 General Chair

It is our great pleasure to welcome all the participants to the “2015 URSI-Japan Radio Science Meeting” (URSI-JRSM 2015) held at O-okayama Campus of Tokyo Institute of Technology, Tokyo, Japan on September 3-4, 2015.

The “URSI-Japan Radio Science Meeting” (URSI-JRSM) is a regional URSI conference organized by the Japan National Committee of URSI, and is held in Japan. The URSI-JRSM provides a scientific forum for radio scientists and engineers in Japan and in the countries of Asia. The objective of the Conference is to review current research trends, present new discoveries, and make plans for future research and special projects in all areas of radio science, and a particular emphasis is placed on promoting URSI activities in the Asian countries. At present, there are only 6 URSI member countries in Asia (China, India, Japan, Korea, Singapore, and Taiwan) and hence, it is desirable to create a cooperative relationship among the URSI national committees in these countries and enhance the visibility of URSI in the Asian region. Therefore the URSI-JRSM also aims at establishing close ties among the URSI Member Committees in Asia.

The URSI-JRSM was held for the first time in Tokyo in September 2014, and it was a success with a series of presentations including 3 Keynote Lectures and 10 Invited Talks by outstanding scientists from Japan and the Asian countries. The URSI-JRSM 2015 is the second URSI-JRSM, and the Conference has been expanded extensively from the first edition from various aspects. The URSI-JRSM 2015 is sponsored by The Institute of Electronics, Information and Communication Engineers (IEICE) and technically supported by the International Union of Radio Science (URSI), in cooperation with various academic organizations including, Japan Geoscience Union, Science Council of Japan, The Astronomical Society of Japan, The Institute of Electrical Engineers of Japan, The Laser Society of Japan, and The Remote Sensing Society of Japan. Subject areas covered by the URSI-JRSM 2015 are broad including topics related to the URSI Commissions A-K. The Conference consists of an oral session with 2 Keynote Lectures, 2 Special Lectures, and 10 Invited Papers by prominent scientists in the radio science community as well as a poster session with a total of 62 contributed papers. In addition to the scientific program, we are also organizing the URSI-Japan Commission Business Meetings during lunch breaks on September 3 and 4, which are open to all the Conference participants. For those of you who are interested in the Commission activities in Japan, please plan on attending these business meetings.

There are several unique features at this year’s URSI-JRSM. We have organized the “Student Paper Competition” (SPC) as a special program for young scientists, which is similar to the program arranged at the “URSI General Assembly and Scientific Symposium” (URSI GASS) and the “URSI Atlantic Radio Science Conference” (URSI AT-RASC). Our SPC program is aimed at encouraging and supporting full-time university students in degree programs so that they will be able to contribute to the URSI community actively. We have received a total of 13 applications for the SPC program. The SPC review process is based on comprehensive evaluations of full-length papers submitted by the applicants and their poster/oral presentations. On Thursday afternoon, September 3, we will select the three finalists after poster presentations by the applicants, and these finalists will be announced at the Banquet held on the same day. Subsequently on Friday morning, September 4, we will judge oral presentations by the three finalists, and select the First, Second, and Third Prize winners. The selection results will be announced at the Award Ceremony held on Friday afternoon, September 4. This SPC program is financially supported by URSI central funds, and the support coming from URSI is greatly acknowledged.

I would also like to mention that we are organizing two special issues based on the papers presented at the URSI-JRSM 2015. One of them is the “Special Issue of the 2015 URSI-Japan Radio Science Meeting”, which is planned to be published in the journal “Radio Science” in 2016. This special issue will provide a collection of papers presented at the URSI-JRSM 2015, and will include invited papers (original and review articles) and contributed papers (original articles). It is aimed at reporting progress and recent advances in the radio science research ranging from fundamental theories to various applications, and covers the areas related to all the URSI Commissions A to K. For those of you who are interested in the special issue in Radio Science, please submit a paper based on your presentation at URSI-JRSM 2015. The other special issue is the “Special Issue on the URSI-JRSM 2015 Student Paper Competition”, which is scheduled for publication in the March 2016 issue of the URSI journal “Radio Science Bulletin”. This special issue will provide a collection of papers by the three winners of the SPC program.

We hope that the “URSI-Japan Radio Science Meeting” (URSI-JRSM) will serve as one of the major, regional URSI conferences in the international radio science community. We would be happy to receive any suggestions on future directions of the URSI-JRSM conferences from all of you attending the URSI-JRSM 2015.

On behalf of the URSI-JRSM 2015 Committees, I would like to express a hearty welcome to all of you working in the area of radio science for your participation in the URSI-JRSM 2015. After the scientific program of the first day is over, the Banquet will be held on campus of Tokyo Institute of Technology in the evening of September 3. We wish that you enjoy the Conference itself as well as the Banquet, and have a pleasant stay in Tokyo. We are hoping that the URSI-JRSM 2015 will lead to a great success and the URSI-JRSM will be held regularly in future.

Welcome to Tokyo, and welcome to the URSI-JRSM 2015!

September 3, 2015

Kazuya Kobayashi
General Chair, 2015 URSI-Japan Radio Science Meeting (URSI-JRSM 2015)
President, Japan National Committee of URSI
URSI Assistant Secretary-General (AP-RASC)
Vice-Chair, URSI Commission B

Sponsorships

This conference is sponsored by:
- The Institute of Electronics, Information and Communication Engineers (IEICE)

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- The Astronomical Society of Japan
- The Institute of Electrical Engineers of Japan
- The Laser Society of Japan
- The Remote Sensing Society of Japan

(in alphabetical order)

Conference Organization

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Yoshiharu Omura, Kyoto University (Past Chair, URSI Commission H)

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Commission G:

Mamoru Yamamoto, Kyoto University (Commission G Official Member, Japan National Committee of URSI)

Commission H:

Yoshiya Kasahara, Kanazawa University (Commission H Official Member, Japan National Committee of URSI)

Commission J:

Kenta Fujisawa, Yamaguchi University (Commission J Official Member, Japan National Committee of URSI)

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Secretariat

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Program and Time Table

Thursday, September 3, 2015

9:00 Opening Ceremony

9:15 Special Lecture 1

Chair: Kazuya Kobayashi (President, Japan National Committee of URSI;
URSI Assistant Secretary-General (AP-RASC); Vice-Chair, URSI Commission B)

Makoto Ando (URSI Vice-President; Tokyo Institute of Technology, Japan)

"International Union of Radio Science (URSI): Its Mission, Structure and Activities"

9:45 Invited Paper 1 (Commission A)

Chair: Mitsuru Musha (Commission A Official Member, Japan National Committee of URSI)

Nozomi Ohtsubo (National Institute of Information and Communications Technology, Japan)

"Present Ion Optical Frequency Standards and New Challenges"

10:15 Coffee Break

10:45 Invited Paper 2 (Commission B)

Chair: Toru Uno (Commission B Official Member, Japan National Committee of URSI)

Toru Sato (Kyoto University, Japan)

"Program of the Antarctic Syowa (PANSY) MST/IS Radar"

11:15 Invited Paper 3 (Commission F)

Chair: Yasuyuki Maekawa (Commission F Official Member, Japan National Committee of URSI)

Yoshio Karasawa (The University of Electro-Communications, Japan)

"On Physical Limit of Wireless Data Transmission from Radiowave Propagation Viewpoint"

11:45 Special Lecture 2

Chair: Makoto Ando (URSI Vice-President)

Kenichi Iga (Professor Emeritus / Former President, Tokyo Institute of Technology, Japan)

"Temperature-Insensitive Quartz Oscillator Enabled Highly Stable Communications and Clocks – Review of Issac Koga's Works –"

12:15 Lunch / Technical Tour / Commission Business Meetings

13:45 Keynote Lecture 1

Chair: Kazuya Kobayashi (President, Japan National Committee of URSI;
URSI Assistant Secretary-General (AP-RASC); Vice-Chair, URSI Commission B)

Alexander I. Nosich (National Academy of Sciences of Ukraine, Ukraine)

"Method of Analytical Regularization in Computational Photonics"

14:30 Invited Paper 4 (Commission K)

Chair: Masao Taki (Past Chair, URSI Commission K)

Koichi Ito (Chiba University, Japan)

"Recent Medical Applications of Electromagnetic Waves"

15:00 Coffee Break / Exhibition

15:30 Poster Session / Exhibition

18:30 Banquet

Friday, September 4, 2015

9:00 Invited Paper 5 (Commission D)

Chair: Katsutoshi Tsukamoto (Commission D Official Member, Japan National Committee of URSI)

Yuichi Kado (Kyoto Institute of Technology, Japan)

"Multi-port Power Router and Its Impact on Future Smart Grid"

9:30 Invited Paper 6 (Commission G)

Chair: Mamoru Yamamoto (Commission G Official Member, Japan National Committee of URSI)

Toshitaka Tsuda (Kyoto University, Japan)

"Study of Coupling Processes in the Solar-Terrestrial System"

10:00 Invited Paper 7 (Commission H)

Chair: Yoshiya Kasahara (Commission H Official Member, Japan National Committee of URSI)

Yohei Miyake (Kobe University, Japan)

"Spacecraft-Plasma Interaction Effects on In-Space Electric Field Measurements"

10:30 Coffee Break

11:00 SPC (Student Paper Competition) Special Session

12:15 Lunch / Technical Tour / Commission Business Meetings

13:45 Keynote Lecture 2

Chair: Jun-ichi Takada (Assistant Secretary, Japan National Committee of URSI)

Ryuji Kohno (Yokohama National University, Japan / University of Oulu, Finland)

"Harmonization Based on Regulatory Science for Scientific and Commercial Radio Uses"

14:30 Invited Paper 8 (Commission C)

Chair: Nobuyoshi Kikuma (Commission C Official Member, Japan National Committee of URSI)

Hiroyuki Tsuji (National Institute of Information and Communications Technology, Japan)

"R&D of Mobile Communication Systems Using Millimeter Wave"

15:00 **Coffee Break**

15:30 **Invited Paper 9 (Commission E)**

Chair: Yasuhide Hobara (Commission E Member, Japan National Committee of URSI)

Yuichi Hayashi (Tohoku Gakuin University, Japan)

"EM Information Leakage from Smart Devices"

16:00 **Invited Paper 10 (Commission J)**

Chair: Kenta Fujisawa (Commission J Official Member, Japan National Committee of URSI)

Masatoshi Ohishi (National Astronomical Observatory of Japan, Japan)

"The Universe, Life and the Radio Sciences"

16:30 **SPC Award Ceremony / Closing Ceremony**

Conference Room Information:

Opening Ceremony …………………………………………. Multi-Purpose Digital Hall, West Building 9
Keynote Lectures, Special Lectures and Invited Papers …….. Multi-Purpose Digital Hall, West Building 9
Closing Ceremony …………………………………………. Multi-Purpose Digital Hall, West Building 9
Poster Session ……………………………………….Media Hall / Collaboration Room, West Building 9
Exhibition ………………………………………………………………….Media Hall, West Building 9
Technical Tour ………………………………………………..Tokyo Tech Museum, Centennial Hall
Banquet ……………………………………………………………………………………Student Hall
Commission Business Meetings …………………West Building 3 / West Building 9 (Details on page 101)

List of Poster Papers

Commission A: Electromagnetic Metrology

A1. Observation of the Magnetic-Insensitive Clock Transition in the $^2S_{1/2}(F=0)$–$^2D_{3/2}(F=2)$ Transitions in Single $^{171}Yb^+$

Yasutaka Imai, Kazuhiko Sugiyama and Masao Kitano (Kyoto University, Japan)

Commission B: Fields and Waves

B1. The Physics of Angular Momentum Radio

Bo Thidé (Swedish Institute of Space Physics & Acreo Swedish ICT AB, Sweden); Fabrizio Tamburini (Twist Off SRL and University of Padua, Italy)

B2. Asymptotic-Numerical Analysis for Transient Scattered Field by a Coated Cylinder with a Thin Lossy Medium Excited by a UWB Pulse Wave

Keiji Goto, Oki Okawa and Naoki Kishimoto (National Defense Academy, Japan)

B3. Preliminary Study of Physical Optics for the Prediction of Scattering from Rough Surface in mmWave

Rieko Tsuji, Kentaro Saito and Jun-ichi Takada (Tokyo Institute of Technology, Japan)

B4. Energy Distribution of Air-hole Waveguides with Dielectric Cylinder Outside of the Defect Layer

Ryosuke Ozaki and Tsuneki Yamasaki (Nihon University, Japan)

B5. Wiener-Hopf Analysis of the Plane Wave Diffraction by a Thin Material Strip

Takashi Nagasaka (Chuo University, Japan)

B6. Maxwell-Schrödinger Hybrid Simulation for Optically Controlling Quantum States: A Two-Level System Manipulated by a Light Pulse Pair

Takashi Takeuchi, Shinichiro Ohnuki and Tokuei Sako (Nihon University, Japan)

Commission C: Radiocommunication Systems and Signal Processing

C1. Twin is Better than Single: A Hybrid Localization Method Using RSS and Time of Flight

Nopphon Keerativoranan (National Electronics and Computer Technology Center, Thailand); Chong-kwon Kim (Seoul National University, Korea)

C2. Localization of Coherent Targets in a Multiple-Input Multiple-Output Radar Employing Spatial Smoothing Between Virtual Antennas Extrapolated From Real Antennas

Ryo Nishikawa and Takehiko Kobayashi (Tokyo Denki University, Japan)

C3. Human Motion Classification Utilizing Radio Signal Strength in Wireless Body Area Network

Sukhumarn Archasantisuk, Takahiro Aoyagi (Tokyo Institute of Technology, Japan); Tero Uusitupa (Aalto University School of Electrical Engineering, Finland); Minseok Kim (Niigata University, Japan); Jun-ichi Takada (Tokyo Institute of Technology, Japan)

C4. Localization of Illegal Radios Utilizing Phase-Difference as Location Fingerprints

Azril Haniz, Gia Khanh Tran, Kei Sakaguchi and Jun-ichi Takada (Tokyo Institute of Technology, Japan); Daisuke Hayashi, Toshihiro Yamaguchi and Shintaro Arata (Koden Electronics Co., Ltd., Japan)

Commission D: Electronics and Photonics

D1. Resonant Tunneling Diode Receivers for 300-GHz-band Wireless Communications

Kousuke Nishio (Osaka University, Japan); Sebastian Diebold (Karlsruhe Institute of Technology, Germany); Shunsuke Nakai (Osaka University, Japan); Kazuisao Tsuruda, Toshikazu Mukai and Jaeyoung Kim (Rohm Co, Ltd., Japan); Masayuki Fujita and Tadao Nagatsuma (Osaka University, Japan)

D2. Study on Hybrid RAN Using RoF and RoR for Distributed Small Cell Configurations

Katsutoshi Tsukamoto and Kazuo Kumamoto (Osaka Institute of Technology, Japan)

D3. Terahertz Wireless Transmission Enabled by Photonics Using Binary Phase-shift Keying at 300 GHz

Yu Yasuda, Yusuke Fujita and Shintaro Hisatake (Osaka University, Japan); Shigeru Kuwano, Jun Terada and Akihiro Otaka (NTT Corporation, Japan); Tadao Nagatsuma (Osaka University, Japan)

Commission E: Electromagnetic Environment and Interference

E1. Electromagnetic Imaging and Monitoring of Active Volcanoes: a Case Study and Future EM Monitoring Plan for Mt. Kusatsu-Shirane Volcano, Japan

Yasuo Ogawa and Mineo Kumazawa (Tokyo Institute of Technology, Japan)

E2. Development of an Upgraded BOLT System to Improve Location Accuracy

Yasuhiro Akiyama, Hiroshi Kikuchi, Ting Wu and Michael Stock (Osaka University, Japan); Yoshitaka Nakamura (Kobe City College of Technology, Japan); Satoru Yoshida (Meteorological Research Institute, Japan); Tomoo Ushio (Osaka University, Japan)

E3. Atmosphere and Ionosphere Connection as Revealed by the Network Observation of Very Low Frequency Radio Signals

Sujay Pal and Yasuhide Hobara (The University of Electro-Communications, Japan)

E4. A Statistical Study of Sub-ionospheric VLF Signal Anomaly Due to Geomagnetic Storms

Kenshin Tatsuta and Yasuhide Hobara (The University of Electro-Communications, Japan)

E5. Statistical Spatial Distributions of Lightning with Charge Moment Changes Over Northern Area of Japan by ELF and LLS Observations

Junpei Yamashita and Yasuhide Hobara (The University of Electro-Communications, Japan)

E6. Modeling and Possible Determination of D-region Ionospheric Perturbation during Annular Solar Eclipse on May 21, 2012, From VLF Signal Simulation and Multi-Propagation Path Observation From UEC-VLF Network: Preliminary Results

Tamal Basak and Yasuhide Hobara (The University of Electro-Communications, Japan)

E7. Bulk Current Injection Simulation Using Integrated Circuit Immunity Macro Model

Yosuke Kondo, Shinichiro Ueyama and Masato Izumichi (DENSO Corporation, Japan); Osami Wada (Kyoto University, Japan)

E8. Estimation of Packet Error Rate Considering Pulse Duration of Burst Disturbance
Kazuhiro Takaya (NTT Corporation, Japan); Daisuke Tomita, Kouki Umeda, Tohlu Matsushima, Takashi Hisakado and Osami Wada (Kyoto University, Japan)

E9. Wideband Characterization of Multilayer Wave Absorber Using FDTD Method
Kosorl Thourn, Takahiro Aoyagi and Jun-ichi Takada (Tokyo Institute of Technology, Japan)

E10. A Novel Prediction for Very Low Frequency Transmitter Signal Amplitude Using NARX Neural Network
Hendy Santosa (The University of Electro-Communications, Japan & University of Bengkulu, Indonesia); Yasuhide Hobara (The University of Electro-Communications, Japan)

Commission F: Wave Propagation and Remote Sensing

F1. Detections of Electromagnetic Pulses During and Prior to Earthquakes
Minoru Tsutsui (Kyoto Sangyo University, Japan)

F2. A Study on Rain Area Motion along the Propagation Path and Ground Wind Velocity Around the Earth Station in Ku-Band Satellite Communications Links
Yasuyuki Maekawa and Yoshiaki Shibagaki (Osaka Electro-Communication University, Japan);

F3. Effects of Rain Area Motion on the Ku-Band Satellite Communications Links in Tropical Wet Season
Akihiro Tama, Yoshiaki Shibagaki and Yasuyuki Maekawa (Osaka Electro-Communication University, Japan)

F4. Effects of Rain Area and Rain Front Velocities on Rain Attenuation Characteristics in Ku-Band Satellite Communications Links
Naoki Kubota, Yoshiaki Shibagaki and Yasuyuki Maekawa (Osaka Electro-Communication University, Japan)

F5. Effects of Rain Area Motion on the Ku-Band Satellite Communications Links in Tropical Dry Season
Keigo Takemoto, Yoshiaki Shibagaki and Yasuyuki Maekawa (Osaka Electro-Communication University, Japan)

F6. Channel Sounding in 2GHz and 60GHz Band for Multi-band Wireless LAN System
Tianyang Min, Kentaro Saito and Jun-ichi Takada (Tokyo Institute of Technology, Japan)

F7. Application of Adaptive Digital Beam Forming for Polarimetric Phased Array Weather Radar
Hiroshi Kikuchi, Takuro Tashima, Ting Wu, Gwan Kim and Tomoo Ushio (Osaka University, Japan); Hideto Goto and Fumihiko Mizutani (Toshiba Corporation, Japan)

F8. Large Scale Subsurface Velocity Estimation with Array GPR System YAKUMO
Li Yi, Kazunori Takahashi and Motoyuki Sato (Tohoku University, Japan)

F9. Enhanced Clustering of Multipath Components Utilizing Geometrical Parameters for Dynamic Indoor Double-Directional Propagation Channel

Panawit Hanpinitsak, Kentaro Saito and Jun-ichi Takada (Tokyo Institute of Technology, Japan); Minseok Kim (Niigata University, Japan)

F10. Fundamental Study of GB-SAR Imaging by Compressive Sensing

Lilong Zou and Motoyuki Sato (Tohoku University, Japan)

F11. Leaf Shape Effects on the Scattering From Simplified Deciduous Leaf Structures Using Spherical Wave Harmonics

Paul Jason Co and Jun-ichi Takada (Tokyo Institute of Technology, Japan)

F12. Experimental Evaluation of UWB Propagation in a Closed Box for Replacing Wired Interface Buses in Spacecrafts

Miyuki Hirose and Takehiko Kobayashi (Tokyo Denki University, Japan)

Commission G: Ionospheric Radio and Propagation

G1. Measurement of Ionosphere over the Western Pacific Ocean

Mamoru Ishii, Hidekatsu Jin, Tatsuhiro Yokoyama, Takuya Tsugawa, Michi Nishioka and Takashi Maruyama (National Institute of Information and Communications Technology, Japan)

G2. Ionospheric Scintillation Observations by a Digital Beacon Receiver in Tromsø

Yasunobu Ogawa (National Institute of Polar Research, Japan); Yuichi Otsuka (Nagoya University, Japan); Mamoru Yamamoto (Kyoto University, Japan)

G3. Development of Digital Receiver for LF/MF Band Radio Wave Onboard Sounding Rocket

Takafumi Mizuno (Toyama Prefectural University, Japan); Yuki Ashihara (Nara National College of Technology, Japan); Keigo Ishisaka (Toyama Prefectural University, Japan)

G4. Electron Density Estimation by Using Simultaneous Observations of Lightning Optical Emissions and Whistlers from ISS GLIMS Mission

Katsunori Suzuki, Yasuhide Hobara and Kanata Kakinuma (The University of Electro-Communications, Japan); Ivan Linscott (Stanford University, USA); Umran Inan (Koc University, Turkey); Mitsuteru Sato and Yukihiro Takahashi (Hokkaido University, Japan); Tomoo Ushio and Zen Kawasaki (Osaka University, Osaka, Japan); Takeshi Morimoto (Kinki University, Japan); Atsushi Yamazaki and Makoto Suzuki (Japan Aerospace Exploration Agency, Japan)

G5. VHF Lightning Observations and DOA Estimation From ISS / JEM-GLIMS

Takeshi Morimoto (Kinki University, Japan); Hiroshi Kikuchi and Tomoo Ushio (Osaka University, Japan); Mitsuteru Sato (Hokkaido University, Japan); Atsushi Yamazaki and Makoto Suzuki (Japan Aerospace Exploration Agency, Japan); Yasuhide Hobara (The University of Electro-Communications, Japan)

G6. Beacon Experiment of Low-latitude Ionosphere from Southeast Asia

Mamoru Yamamoto (Kyoto University, Japan)

G7. GNSS Scintillations and Ambient Ionization near the Northern EIA Crest Under Superstorm Event of March, 2015

Debasis Jana and Shyamal Chakraborty (Raja Peary Mohan College, India)

G8. Estimation of Electron Density Using the Propagation Characteristics of Radio Waves by S-520-29 Sounding Rocket

Keita Itaya and Keigo Ishisaka (Toyama Prefectural University, Japan); Yuki Ashihara (Nara National College of Technology, Japan); Junichi Kurihara (Hokkaido University, Japan); Takumi Abe (Japan Aerospace Exploration Agency, Japan)

Commission H: Waves in Plasmas

H1. A Simple Kinetic-Fluid Model for Ion-Scale Waves in Collisionless Plasmas

Yasuhiro Nariyuki (University of Toyama, Japan); Shinji Saito and Takayuki Umeda (Nagoya University, Japan); Takuma Nakamura (Space Research Institute, Austrian Academy of Sciences, Austria)

H2. Collective Thomson Scattering Diagnostics in Non-Equilibrium Plasma: Application to High Power Laser Experiment

Shuichi Matsukiyo (Kyushu University, Japan); Youichi Sakawa (Osaka University, Japan); Kentaro Tomita (Kyushu University, Japan); Yasuhiro Kuramitsu (National Central University, Taiwan); Hideaki Takabe (Osaka University, Japan)

H3. Dependencies of the Generation Process of Whistler-Mode Emissions on Temperature Anisotropy of Energetic Electrons in the Earth's Inner Magnetosphere

Yuto Katoh (Tohoku University, Japan); Yoshiharu Omura (Kyoto University, Japan); Yohei Miyake and Hideyuki Usui (Kobe University, Japan); Hiroshi Nakashima (Kyoto University, Japan)

H4. Study on Improvement of Direction Finding Method for VLF Waves

Mamoru Ota, Yoshiya Kasahara and Yoshitaka Goto (Kanazawa University, Japan)

H5. Effect of Electron Core-Halo Drift Speed on the Strahl Formation in the Solar Wind: Particle-in-cell Simulations

Jungjoon Seough and Yasuhiro Nariyuki (University of Toyama, Japan); Peter Yoon (University of Maryland, USA); Shinji Saito (Nagoya University, Japan)

H6. Low Frequency Characteristics of a Wire Antenna aboard a Scientific Spacecraft

Tomohiko Imachi (Kanazawa University, Japan); Ryoichi Higashi (Ishiakwa National College of Technology, Japan); Mitsunori Ozaki and Satoshi Yagitani (Kanazawa University, Japan)

H7. Effect of Lunar Surface Reflection on Polarizations of Auroral Kilometric Radiation Observed by KAGUYA

Yoshitaka Goto, Ryota Kimura and Yoshiya Kasahara (Kanazawa University, Japan); Atsushi Kumamoto (Tohoku University, Japan)

H8. Development of Automatic Detection of Omega Signals Captured by PFX Onboard Akebono

I Made Agus Dwi Suarjaya, Yoshiya Kasahara and Yoshitaka Goto (Kanazawa University, Japan)

Commission J: Radio Astronomy

J1. Feasible Spectral Indices Measurement by Broad-band VLBI in VGOS Era
Kazuhiro Takefuji (National Institute of Information and Communications Technology, Japan)

J2. Development of Wide-Band Bandwidth Synthesis Software for Geodetic VLBI
Tetsuro Kondo and Kazuhiro Takefuji (National Institute of Information and Communications Technology, Japan); Yoshihiro Fukuzaki (Geospatial Information Authority of Japan, Japan)

J3. Development of Wideband Feed
Hideki Ujihara (National Institute of Information and Communications Technology, Japan)

J4. New X-band Receiver System of Usuda 64m Antenna
Yasuhiro Murata, Masato Tsuboi, Kentaro Yamaguchi, Kenta Uehara, Hiroshi Takeuchi, Kiyoshi Nakajima, Zen'ichi Yamamoto and Nanako Mochizuki (Japan Aerospace Exploration Agency, Japan); Yusuke Kono, Masahiro Kanaguchi, Syunsaku Suzuki and Tomoaki Oyama (National Astronomical Observatory of Japan, Japan)

J5. Source Frequency Phase Referencing or 22 GHz H2O Masers and 43 and 86 GHz SiO Masers of the Red Supergiant, S Per
Yoshiharu Asaki (National Astronomical Observatory of Japan, Japan)

J6. Hours Timescale Radio Transients Detected by the Nasu Radio Telescope Array
Takahiro Aoki (Waseda University, Japan)

Commission K: Electromagnetics in Biology and Medicine

K1. Microwave Induced Oxidative Stress Mediated Toxicity on Male Fertility Pattern and Possible Protective Measures
Kavindra Kesari (University of Eastern Finland, Finland)

K2. Temperature and Frequency Dependent on Electrical Properties of Swine Liver
Shohei Kon, Kazuyuki Saito and Koichi Ito (Chiba University, Japan)

K3. Development of Biological Tissue Coagulating and Cutting Device Combining Microwave and Radio Frequency Current
Sho Suzuki, Yuta Endo, Kazuyuki Saito and Koichi Ito (Chiba University, Japan)

K4. Study on Cytotoxicity of 0.07-0.30 THz Wave Exposure at Cultured Cells
Noriko Yaekashiwa (RIKEN, Japan); Shin'ichiro Hayashi (RIKEN, Japan); Kodo Kawase (Nagoya University & RIKEN, Japan)

Abstracts
(Keynote Lectures, Special Lectures and Invited Papers)

Method of Analytical Regularization in Computational Photonics

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Thanks to micro and nano technologies, the size of photonic-circuit components is now comparable and even smaller than the length of the electromagnetic wave in the optical range. This makes traditional ray-tracing methods of their analysis and design heavily inaccurate and calls for the full-wave study of the boundary-value problems (BVP) for the time-harmonic-Maxwell equations. Uniqueness of their solution is normally guaranteed by a sufficient set of boundary, edge, and radiation conditions. Although one may try to find it by using finite-difference discretizations of the partial differential equations, associated problems of domain truncation, "good" exterior meshing, and solving enormous matrices are hardly compatible with high accuracy. To avoid these, BVP can be cast to an equivalent integral equation (IE). Then the radiation condition is automatically satisfied and only the finite domains or boundaries need to be discretized.

Many textbooks and journal papers on computational electromagnetics deal with various IEs for determining the surface or polarization currents on metallic or dielectric scatterers, given the incident field. Such IEs are obtained from the Green’s formulas and always have logarithmic or higher singular kernels; many types of them are first-kind IEs. Additionally, some types of IEs loose the equivalence to BVP on discrete sets of frequencies. IEs are frequently discretized for numerical solution with Method-of-Moments (MoM) using subdomain or entire-domain basis functions. Although this commonly brings meaningful and useful results, unfortunately, there are not any theorems proving general MoM convergence, or even the existence of exact solutions, for such IEs [1]. A rule-of-thumb of taking at least 10 mesh points per wavelength is only a rule-of-thumb, and by no means does it guarantee any number of correct digits.

Meanwhile, there exists general approach to obtaining the second kind IEs of the Fredholm type, with a smooth enough kernel, from first-kind equations. Discretization of these new equations generates matrix equations with condition numbers, which remain small if the truncation order is progressively increased. The approach mentioned is collectively called the Method of Analytical Regularization (MAR) [2]; sometimes *semi-inversion* is used as a synonym. It is based on the identification and analytical inversion of the whole singular part of the original IE or its most singular component.

Theoretical merits of the MAR are numerous: exact solution exists, convergence to it is guaranteed, and even asymptotic analytical solution is possible. Computationally, the MAR results in small matrix size for a practical accuracy, and sometimes no numerical integrations are needed for filling in the matrix. Thus, the cost of MAR algorithms is low in terms of both CPU time and memory. A frequent feature is that both power conservation and reciprocity are satisfied at the machine-precision level, whatever is the number of equations. The fact that the condition number is small and stable means that conjugate-gradient numerical algorithms are very promising as emphasized in [3]. It is also important that the accuracy of the MAR is uniform including sharp resonances known as whispering-gallery and lattice ones, which are inaccessible by rough numerical approximations. By now, quite impressive number of optical-wave problems associated with dielectric, metal, semiconductor, and graphene objects has been analyzed with MAR, and interesting effects have been studied in detail and with guaranteed accuracy [4].

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Harmonization Based on Regulatory Science for Scientific and Commercial Radio Uses

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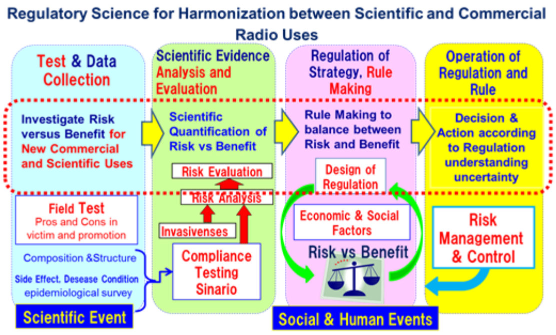
Harmonization for non-commercial scientific radio use such as radio astronomy, medical radio imaging and commercial business radio use such as wireless communications and radio broadcasting must be such an important inherent subject that URSI can discuss and contribute on global rule making from various points of view by a fair manner. For these decades while demand for commercial radio uses has been increasing, commercial radio uses have been always argued to harmonize with non-commercial scientific uses in radio regulation, because it seems to be a difficult problem how the same frequency of radio resources can be shared by both scientific and commercial applications such as radio astronomy observatory and wireless mobile communications. I have also committed in regional and international regulatory committees. For instance, lately ultra wideband (UWB) radio in micro wave and millimeter wave bands have been quite attractive in commercial while radio astronomy observatory using the same band may be interfered. When chairing the committees, it must be quite tough to prove a reasonable judgment while keeping fair balance of long term scientific importance and urgent commercial benefits.

For this discussion on harmonization for non-commercial scientific and commercial business radio uses, we have been taken care in some events of URSI, i.e. special session on URSI-ITU relations in URSI-GASS2011, special workshop on harmonization of scientific and commercial radio uses in AP-RASC2013. However, such argument has not been converged yet while increasing requirement to solve such a problem. The reason why URSI is a best venue to discuss on the harmonization is obvious, because URSI is community of mature representatives of both scientific and commercial radio uses. Scientific use side could be represented by radio astronomy observatory, space agency (ETA, DASA, JAXA, NASA), and radio armature association in commissions F, G, H and J. In commercial use side, there are many representatives from mobile cell phone operators, WiFi or Zigbee industry alliance, and radio broadcasting association in commissions A, B, C, D, E, F, and H.

In this keynote speech in URSI-Japan Radio Science Meeting (URSI-JRSM), I would like to approach to resolve remained issues in the harmonization with "regulatory science," that is a multidisciplinary concept and subject. Regulatory science has been applied for medicine and medical devices for instance because risk versus benefit to apply newly invented medical devices to medical healthcare services can be scientifically analyzed with numerical evaluation. Then a rule or regulation for the devices can be made with scientific manner. Regulatory body will examine the devices and systems compliant to the regulation. A plan of establishing a regulatory science center by Science Council of Japan in Cabinet Office may be also introduced.



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International Union of Radio Science (URSI)
Its Mission, Structure and Activities

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URSI: Mission and Structure

URSI is a non-governmental and non-profit union under the International Council for Science(ICSU). URSI also consists of 44 member committees and 10 scientific commissions as his warp and woof. Its mission, as appears on the Web, is to stimulate and co-ordinate, on an international basis, studies, research, applications, scientific exchange, and communication in the fields of "radio science" or all aspects of electromagnetic fields and waves. Two important objectives are served by the following structures.

1. to represent radio science to the general public and to disseminate the studies and activities in radio science and its applications regionally and globally. Currently, full and associate membership committees are 44 countries/regions.
2. to stimulate and co-ordinate studies of the scientific aspects of electromagnetic waves, that is, telecommunications using guided and unguided, the generation, emission, radiation, propagation, reception, and detection of fields and waves, and the processing of the signals embedded in them. Currently 10 scientific commissions cover the topics in radio science.

URSI: Conference Activities

Historically, URSI has general assemblies (GA) since 1922 and currently every triennial after 1954. GA circulates over the world and the latest one was in 2014 in Beijing China. In GA, the council meeting with membership committees as well as the business meetings with 10 commissions are held and the research trends, new discoveries during the triennium are exchanged and the future planning in the next triennium are discussed. As one of the URSI mission (1), dissemination into developing regions in Asia, Africa and south America should be strengthened. AP-RASC is the regional meeting established in 2001 enhance the visibility of URSI in the Asian countries.

As another mission of URSI (2), since each 10 commission has their own commission specific meetings and academic communities, the unique and distinguishing feature of URSI is to focus upon the interdisciplinary studies between the multi commissions. In addition, to encourage young scientists to contribute to various URSI activities is also an important task of URSI.

URSI: Latest Initiatives

Flagship meetings The Board decided that URSI should focus on yearly URSI "Flagship meetings". These URSI Flagship meetings should allow to maintain the momentum created at the GASS during the triennium. The coming triennium (20115-2017) will be a transition period during which the focus will be on the 2015 AT-RASC meeting and the 2017 GASS. AP-RASC will also be organized in its current format while the transition to an URSI Flagship meeting will be discussed. The commission specific meetings, EMTS of Commission B and ISSSE of Commission C and D for example, can still be held if the Commission wishes to do so. **Early carrier representatives (ECR)** The Board has decided to have two ECR for each commission, which invite the young generation into URSI activities. Now each commission has three officers, the Chair, Vice-Chair and ECR; another ECR will be appointed as the fourth officer.

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Temperature-Insensitive Quartz Oscillator Enabled Highly Stable Communications and Clocks - Review of Issac Koga's Works-

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On April 3, 1933, Issac Koga of Tokyo Institute of Technology, reported quartz crystal cut having the zero temperature coefficient of frequency; R-cut, as shown in Fig. 1. The crystal quartz plate based on this invention was used for transmitters at first and then for clocks. Currently, this type of temperature-insensitive quartz crystal oscillator has become indispensable for radio communication systems and information systems both for professional and consumer electronics.

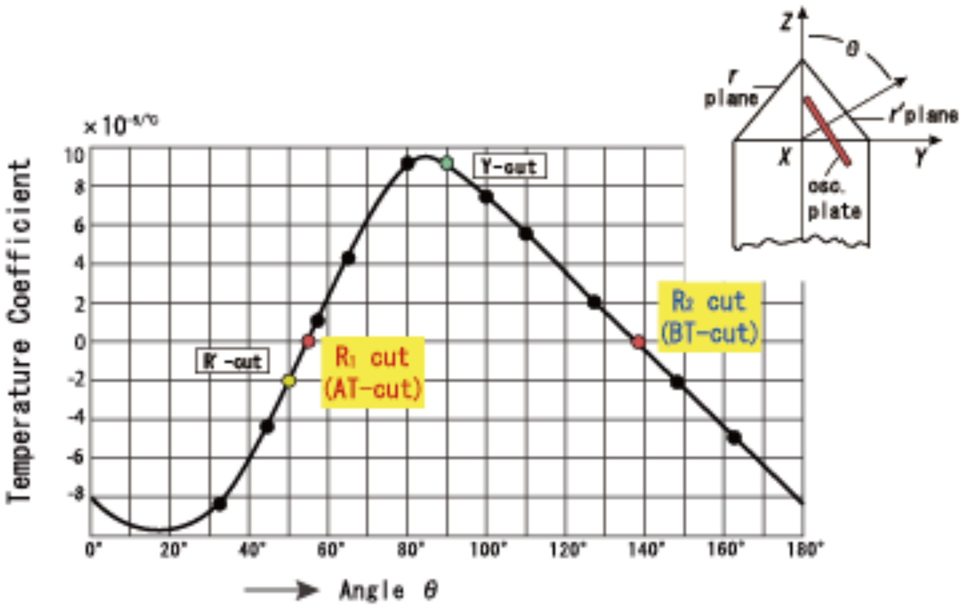

Fig. 1 Temperature coefficients vs. crystal cut angles

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Present ion optical frequency standards and new challenges

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Optical frequency standards realize frequency uncertainty much smaller than those of microwave frequency standards. Relative frequency uncertainty smaller than 10^{-17} has been reported with single-ion optical clocks [1-3] as well as with optical lattice clocks [4]. The optical clocks have their origin in the proposal by H. Dehmelt [5], in which a trapped ion in the alkaline-earth electron configuration (B^+, Al^+, Ga^+, In^+, Tl^+ ;ions of group IIIA) supplies a narrow optical transition free from the quadrupole shift and with negligibly small black body radiation (BBR) shift. This feature enables an inaccuracy in the 10^{-18} level.

Attempts have been made to implement the single-ion optical clock using ions with the alkaline-metal electron structure (Ca^+, Sr^+, Yb^+, Hg^+) instead of those ions in the IIIA group due to difficulty in generating a continuous-wave vacuum ultraviolet (VUV) radiation to laser-cool and to observe the ions. Although the clock transitions of alkaline-metal-like ions are not free from the quadrupole shift and the BBR shift, such progresses as discovery of exceptionally small BBR shift [2], engineering of the trap drive frequency to null the shifts [3] have brought the inaccuracies of the alkaline-metal-like-ion optical clocks down to the 10^{-18} level. Matureness of the quantum information technologies with trapped ions has enabled cooling and detection of IIIA ions without using the VUV radiation. A small-scale quantum computation method called quantum logic spectroscopy (QLS) has been employed to implement a $^{27}Al^+$ optical lock with a relative uncertainty of the 10^{-18} level by NIST group.

Stability of the optical clocks grows as $N^{1/2}$, where N is the number of atoms. The stability of ion clocks can be improved by simultaneous trapping of multiple ions, but this strategy excludes the alkaline-metal-like ions due to the quadrupole shift. The Al^+ optical clock cannot be extended to multiple ions by the limitation of present QLS. We found that the most promising candidate reachable with present technologies is $^{115}In^+$. In our scheme the ions is sympathetically cooled with laser-cooled $^{40}Ca^+$ ions in a linear trap. The clock transition ($^1S_0$-$^3P_0$) is detected by electron shelving using the $^1S_0$-$^3P_1$ transition. This optical clock scheme is directly extended to the multi-ion clock. We have already developed fundamental technologies for implementing the single-ion In^+ clock including resonant photo-ionization, sympathetic cooling, ion sorting [6], deep UV generation with high efficiency, stabilization of the clock laser and generation of the VUV radiation at 159 nm [7]. We will present the details of the experiment and the future prospects of extending the clock to the multi-ion version.

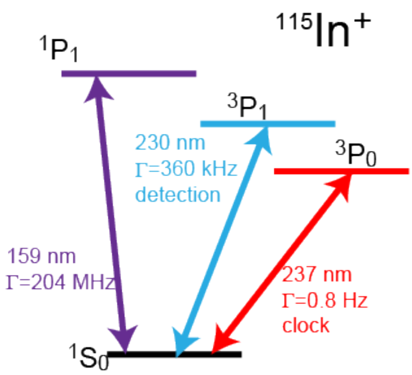

Fig1. Energy diagram of In^+ ion.

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Program of the Antarctic Syowa (PANSY) MST/IS Radar

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The PANSY radar is the first Mesosphere-Stratosphere-Troposphere/Incoherent Scatter (MST/IS) radar in the Antarctic region. It is a large VHF monostatic pulse Doppler radar operating at 47 MHz, consisting of an active phased array of 1,045 Yagi antennas and an equivalent number of transmit-receive (TR) modules with a total peak output power of 500 kW [1]. The construction of the radar system started at Syowa Station (69°00'S, 40°35'E) in 2010, and after operations with partial systems, the full operation was started in March 2015.

Here we briefly review the project's scientific objectives, technical descriptions, and the preliminary results of observations made to date. The radar is designed to clarify the role of atmospheric gravity waves at high latitudes, and to explore the dynamical aspects of unique polar phenomena such as polar mesospheric clouds (PMC) and polar stratospheric clouds (PSC). The katabatic winds as a branch of Antarctic tropospheric circulation and as an important source of gravity waves are also of special interest. Moreover, strong and sporadic energy inputs from the magnetosphere by energetic particles and field-aligned currents can be quantitatively assessed by the broad height coverage of the radar which extends from the lower troposphere to the upper ionosphere.

From engineering points of view, the radar had to overcome restrictions related to the severe environments of Antarctic research, such as very strong winds, limited power availability, short construction periods, and limited manpower availability. We resolved these problems through the adoption of specially designed class-E amplifiers, lightweight and tough antenna elements, and versatile antenna arrangements with flexible electronic control.

Although the radar has so far been operating mainly with partial systems, we have already obtained interesting results on the Antarctic troposphere, stratosphere and mesosphere, such as gravity waves, multiple tropopauses associated with a severe snow storm in the troposphere and stratosphere [1], and polar mesosphere summer echoes (PMSE) and polar mesosphere winter echoes (PMWE) [2].

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On Physical Limit of Wireless Data Transmission from Radiowave Propagation Viewpoint

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Under the steady state condition with thermal noise, the physical limit of information transmission is governed by Shannon's channel capacity theorem. However, in this formula, it does not contain factors of radiowave propagation. In other words, for the ultimate information transmission, a sufficiently long time for the coding and signal processing is expected

However, since wave propagation prevents its premise, there is another physical limit for information transmission in a different perspective with Shannon's channel capacity theorem. Even if the SN ratio is sufficiently high, there is the limit for information transmission. This presentation deals with this matter concerning physical limit of wireless transmission from a radiowave propagation viewpoint.

In wireless data transmission under multipath environment, a condition for not occurring bit errors due to inter-symbol interference (ISI) is σ_τ/T_s <<1 (σ_τ: delay spread of multipath channel, T_s: symbol period of digitally modulated signal). Is this condition truly the physical limit? The answer is NO because it can be solved by employing a waveform equalizer or OFDM transmission scheme based on signal processing using sufficiently long time period than T_s. On the other hand, a condition for not occurring bit errors due to unexpected phase variations by Doppler frequency spread (σ_f) is $\sigma_f T_s$ <<1. Is this condition truly the physical limit? The answer is NO because it can be solved by widening the signal bandwidth adopting such as spread spectrum scheme.

However, for the avoidance, there are the following conditions. To release the condition of σ_τ/T_s << 1, it is necessary for keeping $\sigma_f T_s$ <<1 so that there is no temporal variation during the signal processing period. To release the condition of $\sigma_f T_s$ <<1, it requires frequency-flat fading condition, namely, the condition of σ_τ/T_s << 1. Therefore, the physical limit is truly in the condition of $\sigma_\tau\sigma_f$<<1 which is composed of two major propagation factors: delay spread (σ_τ) and Doppler spread (σ_f). The image is shown in Fig. 1.

In the presentation, we will review this condition to taking future wideband wireless communication systems into consideration. Finnaly, importance of collaboration among antennas (A), propagation (P) and systems (S), namely, APS collaboration, will be stressed.

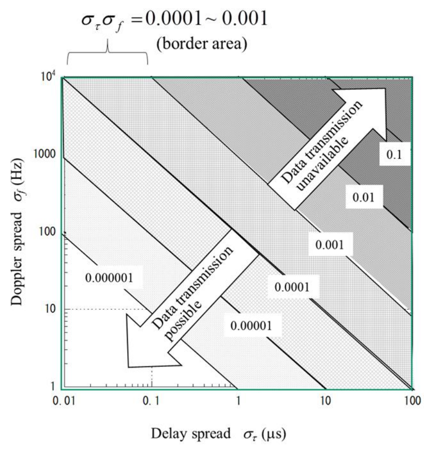

Fig. 1 Data transmission available/unavailable area

Recent Medical Applications of Electromagnetic Waves

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In recent years, various types of medical applications of electromagnetic waves have widely been investigated and reported. Typical recent applications include:

(1) Information transmission:
- RFID (Radio Frequency Identification) tag system / Wearable or Implantable sensor
- Wireless telemedicine / Mobile health system
- Wireless capsule endoscopy

(2) Diagnosis:
- High intensity MRI (Magnetic Resonance Imaging)
- Microwave CT (Computed Tomography) / Radiometry
- Sleep monitor

(3) Treatment:
- Thermal therapy (Hyperthermia, ablation, etc)
- Transcranial magnetic stimulation (TMS)
- Surgical device (Coagulation device, microwave knife, etc)

In this presentation, some practical medical applications of electromagnetic waves which have been studied in our laboratory are introduced. Firstly, a wearable dual-mode antenna [1] for vital data monitoring systems is presented. A key technology for the antenna is body-centric wireless communications. Secondly, an X-band antenna for a microwave sleep monitor is demonstrated with human phantom experiments [2]. A “dynamic” phantom played an important role for the study. Thirdly, after a brief description of thermal therapy and microwave heating, a coaxial-slot antenna and an array applicator composed of several coaxial-slot antennas for minimally invasive microwave thermal therapy are overviewed. A few results of actual clinical trials by use of coaxial-slot antennas are demonstrated from a technical point of view. Then, as a new therapeutic application of coaxial-slot antennas, intracavitary hyperthermia for bile duct carcinoma is briefly introduced [3]. Finally, a few different types of surgical devices using high power microwave energy, including a new coagulation device which can detect the complete coagulation, are introduced [4]. Heating characteristics of such microwave surgical devices are evaluated by numerical calculation as well as some experiments using phantoms, meat and animals.

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Multi-port Power Router and Its Impact on Future Smart Grid

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Through the efforts in achieving security of self-sufficient energy supplies and the prevention of global warming, the effective utilization of electric energy is a critical issue. Therefore, at every stage from power generation to power consumption, it is essential to develop the power electronics technologies that enable efficient power conversion and control. Especially, it's necessary to establish the power interchanging system that can flexibly interchange power among many energy resources, loads, and energy storage devices. Several studies about grid systems have been reported [1], [2], but there is not enough experimental verification about power routers that perform the power interchanging function regardless of DC and AC power and easily construct power networks.

Under such situations, we propose the multi-port power router that can be used as a unit cell to easily build a power delivery system in order to meet many kinds of user's requirements and reduce the system development costs as shown in Fig. 1. The router is composed of a three-way isolated DC/DC converter as a core unit, AC/DC converter units, and a software-defined control unit. The router can distribute power in three directions and perform the power interchanging function regardless of DC and AC. Furthermore, many kinds of loads, energy resources, and energy storage devices are connectable to the routers by only rewriting the control software.

For multiple energy routers installed at various locations to work cooperatively to implement flexible power interchange in real time, as shown in Fig. 2, it is necessary to measure the current and voltage amplitude at each node and reflect the results in the phase-shift modulation (PSM) control of each energy router. We consider the communication requirements of a control framework for enabling dynamic adjustments of power flow through the coordinated operation of multiple energy routers placed in different locations. That requires highly accurate time synchronization of the control modules of the energy routers. A strong candidate for the control network is an optical fiber network access system. When optical fiber is used for high-voltage power converter control, electrical isolation, robustness against lightning strikes, and excellent robustness against electrical noise can be expected.

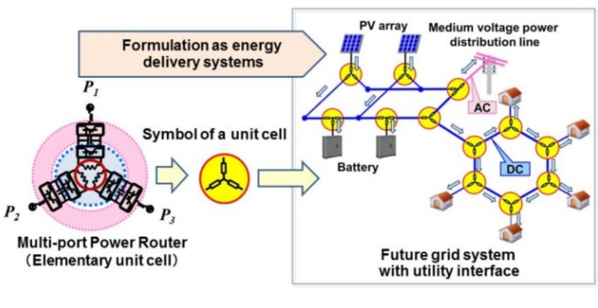

Fig.1. Application of the multi-port power router to future grid systems.

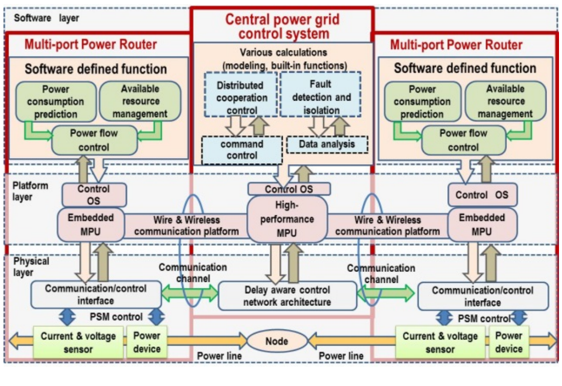

Fig.2. Control layers between energy routers

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Study of Coupling Processes in the Solar-Terrestrial System

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"Coupling process in the solar-terrestrial system" aims to study the solar energy inputs into the Earth, and the response of Geospace (magnetosphere, ionosphere and atmosphere) to the energy input. The solar energy can mainly be divided into two parts - the solar radiation involving infra-red, visible, ultra-violet and X-ray, and solar wind which is a high-speed flow of plasma particles. The solar radiation becomes maximum at the equator; and atmospheric disturbances are actively generated near the Earth's surface. They further excite various types of atmospheric waves which propagate upward carrying energy and momentum. On the other hand, the energy associated with the solar wind converges into the polar regions where disturbances are generated. A part of the energy is transported toward lower latitudes and lower atmospheric regions. We propose to establish large atmospheric radars with active phased array antenna at the equator and the Arctic region. Among the equatorial regions, we focus on the Indonesian region where atmospheric disturbances are most intense. We will establish a comprehensive observatory in Indonesia with the Equatorial MU (EMU) radar as its main facility. Alongside, we will take part in the construction of the state-of-the-art radar, called EISCAT_3D, in northern Scandinavia under international collaborations. We will also develop the global observation network of portable equipment from the equator to both polar regions, and study the flow of the energy and materials in the whole atmosphere.

Spacecraft-Plasma Interaction Effects on In-Space Electric Field Measurements

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Space exploration and exploitation have been rapidly increasing, and a strong demand arises regarding comprehensive understanding of spacecraft-plasma (SP) interactions. This is clearly required to ensure survivability and proper operations of space-based systems, and also for correct interpretation of observation data collected in situ by scientific satellites. In space environments, not only the spacecraft charging but also surrounding plasma disturbances such as caused by the photo-/secondary electron emissions and sheath/wake formations may interfere directly with in-situ electric field measurements using the double probes/electric antennas.

In DC to a low frequency range, the double probe instrument basically measures an electric field as the potential difference between two probe positions. An asymmetric electrostatic environment created near the spacecraft due to sheath/wake formation and photo-/secondary electron emission is thus a potential source of errors in the field measurements. The near-spacecraft potential structure is relevant to the process of spacecraft charging, and the significance of such spurious effects depends strongly on a spacecraft potential.

In a higher frequency range, the response of an antenna to alternating electric field should be characterized by its effective length and RF impedance. Particularly, the antenna impedance in plasma is known to differ from that in free space. Further difficulty is the plasma non-uniformity due to the formation of ion or photoelectron sheaths around the antenna. Since a full treatment of the impedance in magnetized plasma is quite complicated, a simplified model represented by the sheath capacitance and resistance is used commonly. Even using the simplified model, an actual sheath structure should be determined by the complex SP interactions. Hence, the self-consistent solution of such phenomena is necessary to assess these effects.

We apply the plasma particle simulations based on a particle-in-cell (PIC) method to the problems. Our original simulation code EMSES[1] is based on the standard electromagnetic PIC method, and also has the capability to include the conducting bodies of a spacecraft, based on the capacitance matrix method. In addition, a number of physics such as the photoelectron emission and the secondary emission are modeled numerically in the latest version of EMSES. The code has been applied to some specific spacecraft, e.g., Geotail, Cluster[2, 3], BepiColombo/MMO[4], and Solar Probe Plus. In this paper, we present selected examples of the EMSES applications and overview the SP interaction effects on in-space electric field measurements.

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R&D of Mobile Communication Systems Using Millimeter Wave

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Demand has been increasing for better mobile phone and wireless local area network (LAN) access for people on board aircraft or trains. Now, many airline companies have introduced in-cabin use of cellular phones and Internet accesses with a system involving satellites.

The National Institute of Information and Communications Technology (NICT) and Mitsubishi Electric have conducted the research and development of mobile communication systems using high-frequency bands such as the millimeter wave band (40 GHz band), which can provide broadband communication, in order to meet the recent demand for Internet connectivity and high-speed data communication on board fast-moving vehicles such as aircraft and bullet trains [1]. The proposed communication system requires several key technologies such as tracking the target terminal antennas. The ground-based tracking antenna has to continuously track the moving vehicle with a high degree of accuracy. Meanwhile, the onboard antenna has to track the ground-based antenna by considering the moving vehicle attitude and its environment as well. We, therefore, developed a high-accuracy mono-pulse tracking antenna as the ground-based antenna and a downsized active phased array antenna as the on-board antenna.

The ground tracking antenna with a mechanically controlled reflector (Fig. 1) has a feature that enables it to direct its antenna beam in a specific direction by tilting a reflection disk mechanically and to provide a cost-effective and power-efficient tracking antenna. As for the onboard antenna, any onboard antenna equipment must be compact and lightweight. A tracking antenna that is electrically steered is considered suitable for use on an onboard antenna because the phased-array antenna has no moving parts and it can also be resized. We have succeeded in reducing the array antenna's weight by using plastic resin array elements (Fig. 2). We also carried out some experiments using actual airplanes and confirmed that over 100 Mbps transmission speeds could be achieved between the ground and the air.

The results of this research were reflected in the new report ITU-R M.2282: "Systems for public mobile communications with aircraft" in ITU-R SG5 WP5A [2].

We are also trying to deploy this technology on railways, and are promoting research and development to provide broadband access to high-speed trains. To reflect this achievement, we have proposed a new ITU-R report that summarizes the relevant technology in ITU-R SG5 WP5A, and are currently performing studies for the completion of the report.

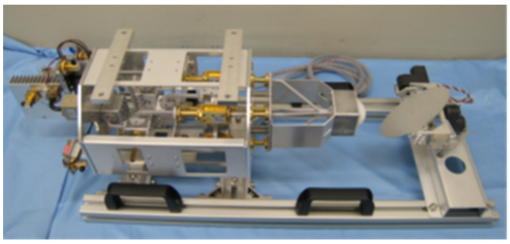

Figure 1. Ground tracking antenna with lens antenna

Figure 2. Onboard active phased array antenna.

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EM Information Leakage from Smart Devices

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At present, ICT devices at risk for EM information leakage include many commercial products, such as CRT and LCD monitors [1, 2], printers [3], keyboards [4], cryptographic modules [5], and so on. In this presentation, we focus on EM information leakage from smart devices (e.g. Tablet PCs, Smartphones). The use of smart devices is spreading rapidly, and accordingly Users browsing and inputting personal information in public spaces can often be seen by third parties. Unlike conventional mobile phones and notebook PCs equipped with distinct input devices (e.g., keyboards), tablet PCs and smartphones have touchscreen keyboards for data input. Such integration of display and input device increases the potential for harm when malicious attackers capture the screen. This presentation introduces a new threat: a capture of tablet PC displays via measurement of electromagnetic (EM) emanation. In conventional studies, such EM display capture has been achieved by using non-portable setups. Those studies also assumed that a significant amount of time was available in advance of arrest to obtain the electrical parameters of the target display. In contrast, this presentation demonstrates that such EM display capture is feasible in real time by a setup that fits in an attaché case. The EM display capture does not require the conventional parameter tuning, relying instead on prior profiling and real-time signal processing. The attack distance makes this method a practical threat to general tablet PCs in public places. We discuss possible attack scenarios based on the setup described above. Also, we describe a mechanism of EM emanation from tablet PCs and a countermeasure against such EM display capture.

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The Universe, Life and the Radio Sciences

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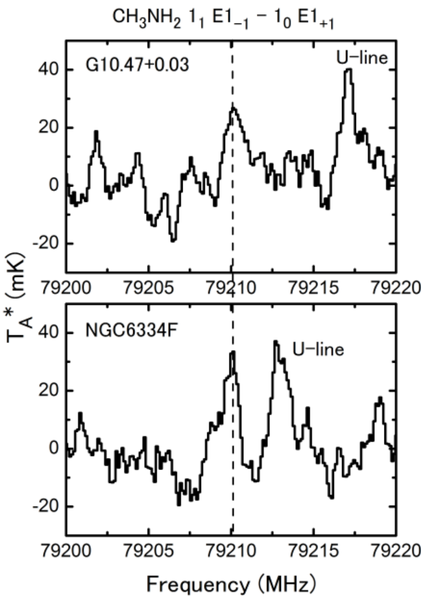
It is widely accepted that prebiotic chemical evolution from small to large and complex molecules would have resulted in the Origin of Life. On the other hand there are two conflicting views where inorganic formation of complex organic molecules (hereafter COMs) occurred in the early Earth, on the Earth or out of the Earth. Ehrenfreund et al.[1] indicated that exogenous delivery of COMs by comets and/or asteroids to the early Earth could be larger than their terrestrial formation by three orders of magnitude. If amino acids are formed in interstellar clouds, significant amount of them may be delivered to planets. Detection of amino acids would accelerate the discussion concerning the universality of "life".

So far, many trials by means of radio telescopes to detect the simplest amino acid, glycine (NH_2CH_2COOH), were made towards Sgr B2 and other high-mass forming regions, but none of them were successful. One idea to overcome this situation would be to search for precursors to glycine. Although the chemical evolution of interstellar N-bearing COMs is not well known, methylamine (CH_3NH_2) is proposed as one precursor to glycine. CH_3NH_2 may be formed through hydrogenation to HCN on dust surface [2][3]: HCN → CH_2NH → CH_3NH_2. Since it is well known that CO_2 exists in most of molecular clouds, glycine would be expected where CH_3NH_2 is rich.



In April 2013, we made a survey to find CH_2NH-rich sources by using the Nobeyama 45 m radio telescope. We succeeded to detect four new CH_2NH sources. The derived fractional abundances of CH_2NH relative to H_2 are as high as $6x10^{-8}$, implying that CH_2NH may exist widely in the Universe. Followed by this success, we made a survey of CH_3NH_2 in 2014, since further hydrogenation to CH_2NH would efficiently produce CH_3NH_2. We succeeded to detect CH_3NH_2 towards two sources as shown in the Figure on the left. The estimated fractional abundance of CH_3NH_2 to H_2 was ~ 10^{-8}, about 10 times higher than that reported towards SgrB2(N) [4]. This result would mean that interstellar glycine is highly expected to exist in various sources. We would be able to find more CH_3NH_2-rich sources by observing the 79 GHz region.

However, a serious problem may occur in the 76 to 81 GHz range. Car manufacturers have strongly pushed to use this frequency range for automobile radars. Improving safety is very important, however, unless an exclusion zone is established around each radio observatory operating in the 76 to 81 GHz range, highly sensitive radio astronomical observations would become impossible !

URSI is one of the right fora to find measures for various radio uses to coexist.

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Biographical Sketches of Speakers

Keynote Lecture 1: "Method of Analytical Regularization in Computational Photonics"

Prof. Alexander I. Nosich, ***National Academy of Sciences of Ukraine, Ukraine***

Alexander I. Nosich is Professor and Principal Scientist of the Institute of Radio-Physics and Electronics of the National Academy of Sciences of Ukraine, Ukraine. He was born in Kharkiv, Ukraine, in 1953. He earned his M.S., Ph.D. and D.Sc. degrees, in Radio Physics, from the Kharkiv National University in 1975, 1979 and 1990, respectively. Since 1979, he has been with the Institute of Radio-Physics and Electronics of the National Academy of Sciences of Ukraine in Kharkiv, currently as Principal Scientist, Professor, and Head of the Laboratory of Micro and Nano Optics. Since 1992, he has held many guest fellowships and professorships in the EU, Japan, Singapore, and Turkey. In 1990 he was one of the initiators and then technical program committee chairman of the international conference series on Mathematical Methods in Electromagnetic Theory (MMET) held in Ukraine. In 1995, he organized the IEEE Antennas and Propagation Society East Ukraine Chapter, the first one in the former USSR. In 2001-2003, he represented Ukraine, Poland and the Baltic States in the European Microwave Association. Since 2008, he represents Ukraine and Georgia in the European Association on Antennas and Propagation. He was elected Fellow of IEEE in 2004, via the Antennas and Propagation Society, and Senior Member of the Optical Society of America in 2012. In 2015, he was awarded the title of Doctor Honoris Causa of the University of Rennes 1, France. His research interests include the method of analytical regularization, propagation and scattering of waves, open resonators, open waveguides, optical antennas, linear modeling of lasers, and the history of microwaves.

Keynote Lecture 2: "Harmonization Based on Regulatory Science for Scientific and Commercial Radio Uses"

Prof. Ryuji Kohno, ***Yokohama National University, Japan / University of Oulu, Finland***

Ryuji Kohno is IEEE and IEICE fellows. He received the Ph.D. degree in Dept.EE from the Univ. of Tokyo in 1984. Since 1998 he has been a Professor in YNU. During 1984-1985 he was a Visiting Scientist in Dept.EE, Univ. of Toronto. Since 2007, he is also a Finnish Distinguished Professor (FiDiPro) in Univ. of Oulu, Finland. The meanwhile, he was also a director of SONY CSL/ATL during 1998-2002 and was a director of the UWB Tech. Inst. and a program coordinator of Medical ICT Inst. of National Institute of Information and Communications Technology (NICT) during 2002-2011. Currently he is the CEO of the University of Oulu Research Institute Japan – CWC-Nippon Inc. Ltd. since March 2012. He was a principal leader of MEXT 21st century and Global COE programs during 2002-2007 and 2008-2013, respectively. Since 2003, he is currently a director of both Medical ICT Center and Kanagawa Medical Device Regulatory Science Center in YNU. He is an associate member of the Science Council of Japan since 2006. Prof. Kohno was elected to be a BoG member of the IEEE Information Theory Society three times on 2000, 2002, and 2006. He was awarded IEICE Greatest Contribution Award and NTT DoCoMo Mobile Science Award in 1999 and 2002, respectively.

Special Lecture 1: "International Union of Radio Science (URSI): Its Mission, Structure and Activities"

Prof. Makoto Ando, ***URSI Vice-President; Tokyo Institute of Technology, Japan***

Makoto Ando received the D.E. degrees in electrical engineering from Tokyo Institute of Technology, Tokyo, Japan in 1979. From 1979 to 1983, he worked at Yokosuka Electrical Communication Laboratory, NTT, and was engaged in development of antennas for satellite communication. He moved to Tokyo Institute of Technology in 1983 and is currently a Professor and the Executive Vice President for research of the Tokyo Institute of Technology. His main interests have been high frequency diffraction theory such as Physical Optics and Geometrical Theory of Diffraction. His research also covers the design of waveguide planar arrays and millimeter-wave antennas. He received the Achievement Award and the Paper Awards from IEICE Japan in 1993 and 2009. He also received the 8th Inoue Prize for Science in 1992, the Meritorious Award of the Minister of Internal Affairs and Communications and the Chairman of the Broad of ARIB in 2004 and the Award in Information Promotion Month 2006, the Minister of Internal Affairs and Communications. He received IEICE Distinguished Achievement and Contributions Award in 2014.

He served as the guest editor-in-chief of more than six special issues in IEICE, Radio Science and IEEE AP. He was the general chair of the 2004 URSI EMT symposium in Pisa and of the ISAP 2007 in Niigata. He was the Program Officer for engineering science group in Research Center for Science Systems, JSPS in 2006-2009. He served as the member of Scientific Council for Antenna Centre of Excellence - ACE in EU’s 6’th framework programme since 2004. He served as the Chair of Commission B of URSI 2002-2005. He was the 2007 President of Electronics Society IEICE, the 2009 President of IEEE Antennas and Propagation Society and is currently the Co-chair of ISAP International Steering Committee and vice-president of URSI and IEICE. He is the Fellow IEEE and IEICE.

Special Lecture 2: "Temperature-Insensitive Quartz Oscillator Enabled Highly Stable Communications and Clocks – Review of Issac Koga's Works –"

Prof. Emeritus Kenichi Iga, ***Professor Emeritus / Former President, Tokyo Institute of Technology, Japan***

Kenichi Iga received the B.E., M.E., and Dr. Eng. degrees from the Tokyo Institute of Technology, in 1963, 1965 and 1968, respectively. From 1968, he joined the P&I Lab., Tokyo Institute of Technology, became Associate Professor in 1974 and Professor in 1984. He retired Tokyo Institute of Technology in March 2001 and was awarded by Professor Emeritus.

Dr. Iga joined Japan Society for the Promotion of Science (JSPS) as Executive Director from April 2001 to September 2007. He has been serving as the President of Tokyo Institute of Technology from October 2007 till September 2012. From 1979 to 1980, he stayed at Bell Laboratories as Visiting Technical Staff Member.

Prof. Iga first proposed and pioneered the research of surface emitting laser (VCSEL) and microoptics. He received 1992 IEEE/LEOS William Streifer Award, 1998 IEEE/OSA John Tyndall Award, 2003 IEEE Daniel E. Noble Award, 2002 Rank Prize, 2001 Purple Ribbon Prize, 2003 Fujiwara Award, 2007 C&C Prize, and 2009 NHK Broadcast Cultural Award. In 2013, he was awarded 2013 Franklin Medal with the Bower Award and Prize in Science.

Invited Paper 1 (Commission A):

"Present Ion Optical Frequency Standards and New Challenges"

Dr. Nozomi Ohtsubo, ***National Institute of Information and Communications Technology, Japan***

Nozomi Ohtsubo received the B. S., M. S. degrees from Keio University, Japan, in 2008 and 2010, the Ph.D. degree from University of Tokyo, Japan, in 2013. He joined National Institute of Information and Communications Technology (NICT) as a post-doctoral researcher in 2013. He is engaged in the ion optical frequency standard.

Invited Paper 2 (Commission B):

"Program of the Antarctic Syowa (PANSY) MST/IS Radar"

Prof. Toru Sato, ***Kyoto University, Japan***

Toru Sato received his B.E., M.E., and Ph.D. degrees in electrical engineering from Kyoto University, Kyoto, Japan in 1976, 1978, and 1982, respectively. He has been with Kyoto University since 1983 and is currently a Professor in the Department of Communications and Computer Engineering, Graduate School of Informatics. His major research interests include system design and signal processing aspects of UWB radars, atmospheric radars, radar remote sensing of the atmosphere, and biomedical imaging. He is a fellow of the Institute of Electronics, Information, and Communication Engineers of Japan, and a member of the Society of Geomagnetism and Earth, Planetary and Space Sciences, the Japan Society for Aeronautical and Space Sciences, the Institute of Electrical and Electronics Engineers, and American Meteorological Society.

Invited Paper 3 (Commission F):

"On Physical Limit of Wireless Data Transmission from Radiowave Propagation Viewpoint"

Prof. Yoshio Karasawa, *The University of Electro-Communications, Japan*

Yoshio Karasawa received B.E. degree from Yamanashi University in 1973 and M.E. and Dr. Eng. Degrees from Kyoto University, Japan, in 1977 and 1992, respectively. He joined KDD R&D Labs. in 1977. From July 1993 to July 1997, he was a Department Head of ATR Optical and Radio Communications Res. Labs. and ATR Adaptive Communications Res. Labs. both in Kyoto. Since 1999, he has been a professor in the University of Electro-Communications (UEC), Tokyo, and acted as the first director of Advanced Wireless Communication research Center (AWCC) in UEC from 2005 to 2007. He has engaged in studies on wave propagation and antennas, particularly on theoretical analysis and measurements for wave-propagation phenomena, such as multipath fading in mobile radio systems, tropospheric and ionospheric scintillation, and rain attenuation. His recent interests are in frontier regions bridging "wave propagation" and "digital transmission characteristics" in wideband mobile radio systems such as MIMO. In the field of wireless communications, particularly of radiowave propagation, he authored/co-authored 10 text books, more than 200 journal papers, and 200 international conference papers.

Dr. Karasawa received the Young Engineer Award from IECE of Japan in 1983, the Meritorious Award on Radio from the Association of Radio Industries and Businesses (ARIB, Japan) in 1998, Research Award from ICF in 2006, two Paper Awards from IEICE in 2006, and Best Tutorial Paper Awards in 2007 and 2008 from ComSoc of IEICE. He is a fellow of the IEEE and IEICE.

Invited Paper 4 (Commission K):

"Recent Medical Applications of Electromagnetic Waves"

Prof. Koichi Ito, *Recent Medical Applications of Electromagnetic Waves*

Koichi Ito received the B.S. and M.S. degrees from Chiba University, Japan, and the D.E. degree from Tokyo Institute of Technology, Japan. He is currently a Professor at the Center for Frontier Medical Engineering, Chiba University. From 2005 to 2009, he was Deputy Vice-President for Research, Chiba University. From 2009 to 2015, he served as Director of the Center for Frontier Medical Engineering, Chiba University.

His main research interests include small antennas for mobile communications, microwave antennas for medical applications such as cancer treatment, research on evaluation of the interaction between electromagnetic fields and the human body by use of phantoms, and antenna systems for body-centric wireless communications.

Professor Ito is a Fellow of the IEEE, a Fellow of the Institute of Electronics, Information and Communication Engineers, Japan (IEICE). He served as Chair of the Technical Committee on Human Phantoms for Electromagnetics, IEICE, from 1998 to 2006, Chair of the Technical Committee on Antennas and Propagation, IEICE, from 2009 to 2011, Chair of the IEEE AP-S Japan Chapter from 2001 to 2002, General Chair of the 2008 IEEE International Workshop on Antenna Technology (iWAT2008), an AdCom member for the IEEE AP-S from 2007 to 2009, an Associate Editor for the IEEE Transactions on Antennas and Propagation from 2004 to 2010, a Distinguished Lecturer for the IEEE AP-S from 2007 to 2011, General Chair of the 2012 International Symposium on Antennas and Propagation (ISAP2012), and a member of the Board of Directors, BEMS, from 2010 to 2013. He currently serves as Chair of the IEEE AP-S Committee on Man and Radiation (COMAR) and a Councilor to the Asian Society of Hyperthermic Oncology (ASHO). He has been elected as a delegate to the European Association on Antennas and Propagation (EurAAP) since 2012 and Chair of Commission K, Japan National Committee of URSI (International Union of Radio Science) since 2015.

Invited Paper 5 (Commission D):

"Multi-port Power Router and Its Impact on Future Smart Grid"

Prof. Yuichi Kado, ***Kyoto Institute of Technology, Japan***

Yuichi Kado received M.S. and Ph.D. degrees in electronics from Tohoku University, Miyagi, Japan, in 1983 and 1998, respectively. In 1983 he joined the Electrical Communication Laboratories of Nippon Telegraph and Telephone Public Corporation (now NTT), Kanagawa, Japan, where he was engaged in research on SOI structure formation by hetero-epitaxial growth. From 1989 to 1998 he worked on the development of fully depleted CMOS/SIMOX LSIs and ultra-low-power CMOS circuits. From 1999 he was engaged in R&D on compact network appliances using ultralow-power CMOS circuit technologies for ubiquitous communications. He led research and development projects on ultra-low-power network appliances, sub-terahertz-wave wireless communication, and intra-body communication as a director of Smart Devices Laboratory at NTT Microsystem Integration Laboratories (2003-2010). In July 2010, he joined the Department of Electronics, Kyoto Institute of Technology, Kyoto, Japan. His current research interests include multi-port power router to build energy interchanging systems and human body communication. He has been the recipient of awards including the 2009 Nikkei BP Technology Award, the 2009 Radio wave Achievement Award presented by the ARIB, and the 2009 Telecom System Technology Award presented by the Telecommunications Advancement Foundation. He is a board member of NPERC-J (http://www.nperc-j.or.jp) and a member of IEEE.

Invited Paper 6 (Commission G):

"Study of Coupling Processes in the Solar-Terrestrial System"

Prof. Toshitaka Tsuda, ***Kyoto University, Japan***

Toshitaka Tsuda received B. Eng., M. Eng., and Dr. Eng. degrees in Electronics from Kyoto University in 1975, 1977, and 1982, respectively. He was Assistant Professor in Electronics, Kyoto University since 1977 and Associate Professor in Radio Atmospheric Science Center (RASC), Kyoto University since 1987. From 1995, he became Professor at RASC, Kyoto University. He is currently Director and Professor (Laboratory of Atmospheric Sensing and Diagnosis) in Research Institute for Sustainable Humanosphere (RISH), Kyoto University, and Vice Executive Director, Kyoto University. His research area is observational studies of the middle and upper atmosphere dynamics and meteorology with atmospheric radars and GPS meteorology techniques, and development of new radio and optical remote-sensing techniques. He is the President of Japan Geoscience Union (JpGU) since May, 2012, and a liaison-member of Science Council of Japan since September, 2006. He served Co-Chair of Climate and Weather of the Sun-Earth System (CAWSES) Ⅱ which is an international program sponsored by Scientific Committee on Solar-Terrestrial Physics (SCOSTEP) of ICSU in 2009-2013. He was awarded Tanakadate Award (SGEPSS) in 1985, Horiuchi Award (Meteorological Society of Japan) in 1994, and Society Award (Meteorological Society of Japan) in 2003. He is also an ISI highly cited scientist in Geoscience.

Invited Paper 7 (Commission H):
"Spacecraft-Plasma Interaction Effects on In-Space Electric Field Measurements"
Assist. Prof. Yohei Miyake, ***Kobe University, Japan***

Yohei Miyake received his B.E., M.E., and Dr. Eng. degrees in electric engineering from Kyoto University in 2004, 2006, and 2009, respectively. He was a post-doctoral researcher of the Academic Center for Computing and Media Studies, Kyoto University from 2009 to 2011. Since 2011, he has been with the Graduate School of System Informatics and the Education Center on Computational Science and Engineering, Kobe University. In 2014, he became an assistant professor in the Graduate School of System Informatics, Kobe University. He has been engaged in the study of spacecraft-plasma interactions and high-performance computing in plasma physics. He was awarded URSI Young Scientist Award in 2005. He is a member of Society of Geomagnetism and Earth, Planetary and Space Sciences (SGEPSS), Japan Geoscience Union (JpGU), American Geophysical Union (AGU), and Japan Society for Computational Engineering and Science (JSCES).

Invited Paper 8 (Commission C):
"R&D of Mobile Communication Systems Using Millimeter Wave"
Dr. Hiroyuki Tsuji, ***National Institute of Information and Communications Technology, Japan***

Hiroyuki Tsuji received B.E., M.E., and D.E. degrees in Electrical Engineering from Keio University, Tokyo, Japan, in 1987, 1989, and 1992, respectively. In 1992, he joined the Communications Research Laboratory (CRL, now part of the National Institute of Information and Communications Technology, or NICT). From 1999 to 2000, he was a visiting research fellow of the University of Minnesota. Since 2002, he has been working at Yokohama National University, Yokohama, Japan as a visiting professor, which is an additional post. His research interests are array antennas for wireless communications and signal processing for communications and other systems. Dr. Tsuji received the Young Engineer Award from IEICE (The Institute of Electronics, Information and Communication Engineers) of Japan in 1995, the Electrical Science and Engineering Promotion Award from the Promotion Foundation for Electrical Science and Engineering in 2010, and ITU-AJ Encouragement Award from the ITU Association of Japan (ITU-AJ) in 2014, respectively. He is a member of IEICE of Japan.

Invited Paper 9 (Commission E):

"EM Information Leakage from Smart Devices"

Assoc. Prof. Yuichi Hayashi, *Tohoku Gakuin University, Japan*

Yuichi Hayashi received the B.E. degree in computer science and engineering from Aizu University, Aizuwakamatsu, Japan, in 2003, and the M.S. and Ph.D. degrees in information sciences from Tohoku University, Sendai, Japan, in 2005 and 2009, respectively. He is currently an Associate Professor at the Faculty of Engineering, Tohoku Gakuin University.

His research interests include electromagnetic compatibility and information security. He is the Chair of Electromagnetic Information Leakage Subcommittee in IEEE Electromagnetic Compatibility Technical Committee 5.

He received IEEE EMC International Symposium on Electromagnetic Compatibility Best Symposium Paper Award in 2013, Symposium on Cryptography and Information Security Innovation Paper Award in 2014 and 2015, Research Institute of Electrical Communication (RIEC) Award at Tohoku University in 2014, and Workshop on Cryptographic Hardware and Embedded Systems (CHES) Best Paper Award in 2014.

Invited Paper 10 (Commission J):

"The Universe, Life and the Radio Sciences"

Assoc. Prof. Masatoshi Ohishi, *National Astronomical Observatory of Japan, Japan*

Masatoshi Ohishi, the Director of the Astronomy Data Center, the National Astronomical Observatory of Japan (NAOJ), is an active radio astronomer with a broad scientific background.

He has deep knowledge and experience on the molecules in space (interstellar molecules), and he and his colleague discovered many new interstellar molecules by using the 45m radio telescope of the Nobeyama Radio Observatory, NAOJ. His current scientific interest is on exogenous delivery of prebiotic material from interstellar space to planets, as an origin of life.

He has variety of international activities: he was the president of Commission 5 (Astronomical Data) of the International Astronomical Union (IAU) between 2009 and 2012. He serves the vice president of an IAU Commission, Astrobiology, between 2015 and 2018. Since 1993 he joined the International Telecommunication Union (ITU) in order to protect the radio astronomy observations against man-made interference. He was the chairman of Working Party 7D (radio astronomy) of the Radiocommunications Sector of the ITU, between 2000 and 2010.

He is a member of the IAU, the URSI and the Committee on Space Research (COSPAR).

Abstracts
(Contributed Poster Papers)

Observation of the Magnetic-Insensitive Clock Transition in the $^2\mathrm{S}_{1/2}(F=0)-^2\mathrm{D}_{3/2}(F=2)$ Transitions in Single $^{171}\mathrm{Yb}^+$

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Optical clocks referenced to long-lifetime transitions in isolated atoms or ions in optical region have a potential for better uncertainty than that of the current frequency standard defined in microwave region. Extremely low uncertainties in optical clocks enable us to conduct precise tests in the field of fundamental physics such as search for a time variation of the fine structure constant α [1].

We aim at realization of optical clocks based on single $^{171}\mathrm{Yb}^+$ ions. $^{171}\mathrm{Yb}^+$ has the $m_F = 0 - m_{F'} = 0$ clock transitions, which are free from the 1st-order Zeeman shift. Also, $^{171}\mathrm{Yb}^+$ has relatively simple hyperfine structures. A large difference in the sensitivity to the variation of α between the quadrupole and octupole clock transitions enables us to search for a time variation of α by using only $^{171}\mathrm{Yb}^+$ ions [2, 3]. In this work, we conduct single-ion spectroscopy of the $^2\mathrm{S}_{1/2}(F=0)-^2\mathrm{D}_{3/2}(F=2)$ clock transitions in $^{171}\mathrm{Yb}^+$, and identify the $m_F = 0 - m_{F'} = 0$ component.

The $^2\mathrm{S}_{1/2}(F=0)-^2\mathrm{D}_{3/2}(F=2)$ transition has five Zeeman components corresponding to $\Delta m_F = 0,\ \pm1,\ \pm2$. In order to identify the $m_F = 0 - m_{F'} = 0$ component, we probed all Zeeman components by frequency sweep of the clock laser by 20-kHz intervals. The result is shown in Fig. 1. We identified the $m_F = 0 - m_{F'} = 0$ component. We conducted spectroscopy with higher resolution and resolved motional sidebands. Then, we probed the carrier spectrum with even higher resolution. We detected the spectra two times by changing the sweep direction of the clock-laser frequency, in order to measure and remove a linear frequency drift in the clock laser. We obtained a spectrum of the full width at half maximum of 380 Hz as shown Fig. 2.

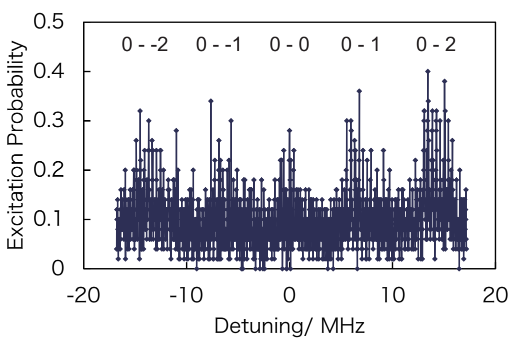

Figure 1. All zeeman components of the $^2\mathrm{S}_{1/2}(F=0)-^2\mathrm{D}_{3/2}(F=2)$ transition detected by using a single $^{171}\mathrm{Yb}^+$ ion.

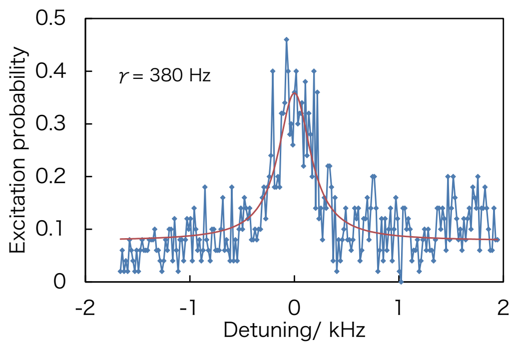

Figure 2. Carrier spectrum of the $m_F = 0 - m_{F'} = 0$ component. Frequency is swept in 20-Hz intervals.

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The Physics of Angular Momentum Radio

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Radio science and technology, be it fundamental physical or information-theoretical research, implementations such as radio astronomy and radar probing, or wireless communication and navigation applications, currently use predominantly techniques that involve only the Poynting (linear momentum density) vector. I.e., the methods used are almost entirely based on the electromagnetic linear (translational) momentum physical layer.

As a complement and/or supplement to this conventional approach, innovative techniques rooted in the electromagnetic angular (rotational) momentum physical layer have been advocated, and promising results from proof-of-concept laboratory and real-world angular momentum wireless and fiber communication experiments were recently reported. A physical observable in its own right, albeit much more sparingly used than other electromagnetic observables such as the energy and linear momentum, the angular momentum exploits the rotational symmetry of the electromagnetic field and the rotational (spinning and orbiting) dynamics of the pertinent charge and current densities.

We have shown that the volume integrated angular momentum density, i.e., the total angular momentum emitted by any source, always tends asymptotically to a constant when the distance from the source volume tends to infinity. This proves that a radiation arrow of time exists also for angular momentum, as it does for linear momentum (the volume integrated Poynting vector) and that therefore angular momentum physics (torque action) offers an alternative or a supplement to conventional linear momentum physics (force action) as a means of transferring information wirelessly over very long distances. This proof opens possibilities for, among other things, a more flexible utilization of the radio frequency spectrum and paves the way for new information transfer methodologies, technologies and techniques. We discuss implementation aspects and illustrate them by examples based on analytic and numerical analyses.

We report results from experiments demonstrating the feasibility of using electromagnetic angular momentum (vortices) in real-world applications, and how vortical (twisted) beams can be shaped and their divergence controlled. A scenario with angular momentum transducers of new types, including optomechancial ones and those based on the interplay between charge, spin and orbital angular degrees of freedom, heralded by recent advances in spintronics/orbitronics, condensed-matter skyrmion, and quantum ring physics and technology, is briefly delineated.

Asymptotic-Numerical Analysis for Transient Scattered Field by a Coated Cylinder with a Thin Lossy Medium Excited by a UWB Pulse Wave

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The studies on high-frequency scattering analysis by a smooth convex body have been an important research subject in the area of the analysis of radiation patterns of antennas mounted near curved surfaces such as an aircraft fuselage and the radar cross section of an airborne vehicle [1].

We have derived a frequency-domain (FD) uniform asymptotic solution (FD-UAS), which is useful for engineering applications, for a two-dimensional scattering problem by a coated conducting cylinder covered with a thin lossy medium [2]. The FD-UAS is uniform in the sense that it remains valid within the transition region adjacent to the shadow boundary, and it smoothly connects a geometric optical ray (GO) solution and a geometrical theory of diffraction (GTD) solution exterior to the transition region, respectively. The FD-UAS is valid for a source point and an observation point either near the coating surface or in the far-zone. The FD-UAS is represented by a combination of scattered field component solutions, namely, the geometric optical ray (GO) solution composed of a direct GO (DGO) and a reflected GO (RGO), the extended uniform GTD (UTD) solution made up of a DGO and a pseudo surface diffracted ray (pseudo SD), the modified UTD solution representing SD series, and the lowest order SD solution.

In this paper, by extending the FD-UAS in [2], we derive a TD asymptotic-numerical solution (TD-ANS) for the transient scattered field when a modulated ultra-wideband (UWB) pulse wave [3] is incident on a coated cylinder with a thin lossy medium [4]. We assume that the thickness of the medium is thin as compared with the wavelength of a central angular frequency of a UWB pulse wave. The TD-ANS is represented by a combination of transient scattered field component solutions, namely, the GO solution, the extended UTD solution, the modified UTD solution, and the lowest order SD solution.

The validity and computation rate of the TD-ANS is confirmed by comparing with a reference solution which is computed numerically by applying the FD exact solution and the FFT numerical code to a transient scattered field integral. We show that the TD-ANS is effective in understanding the transient scattering phenomena of a coated cylinder, because it can extract and observe each pulse wave element from the response waveform even when the pulse wave elements overlap mutually.

Acknowledgments
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Preliminary Study of Physical Optics for the Prediction of Scattering from Rough Surface in mmWave

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As the demands for high speed wireless communications increase, the utilization of mmWave in the mobile wireless networks have become a topic of great interest. In those higher frequency band, it is thought that the wave scattering becomes dominant propagation mechanism since the wavelength is relatively same size to the roughness of objects' surface [1]. However, scattering phenomenon is not fully clarified. Physical Optics (PO) is an effective method to obtain electromagnetic fields of scattering with approximating the induced current focusing on a locality of the scattering area. In this paper, we present the received power characteristics scattered from a random rough surface which is characterized by rms height h with Gaussian distribution and correlation length l with Gaussian correlation [2], calculated by PO. We also discuss the appropriate integral area introducing Fresnel Zone, which are transformed as an ellipse depends on the incident angle.

Figure 1. shows simulation setting. As we consider mmWave and indoor environment, such as a wall with random objects like pipes, h is set as 1λ (10 to 1 mm) and l is set as 5λ (50 to 1 mm).

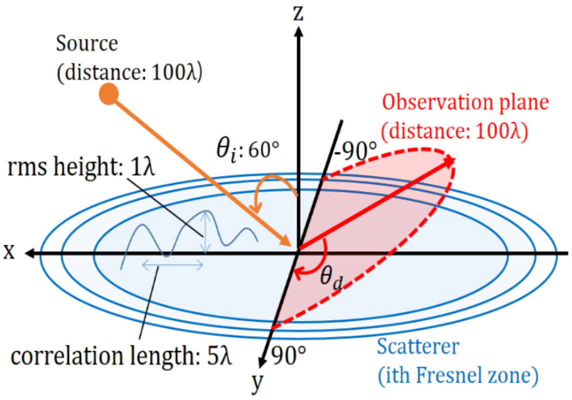

Figure 1. Simulation Setting.

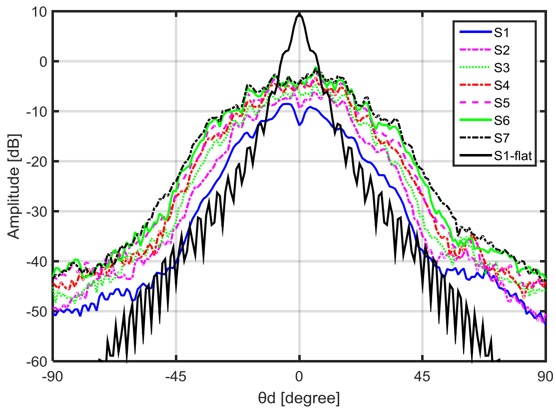

Figure 2. Received Power Comparison (θcomponent).

Figure 2. shows the result of the received power comparison in terms of the integral area. In this figure, the integral areas are represented by the number of fresnel zone and the index of S refers the number in the legend. Black line represent the received power from a flat surface by integral area of S1. You can observe that the peak power of S1 is almost 20 dB less than S1-flat, and the power spread much wider than S1. More specific, rms angular spread of S1 is 12.09 degree while it is 3.85 degree in case of S1-flat. Switching our attention to the integral area, the peak received power difference between S3 and S4 is 2.04 dB, while it is 0.25 dB in case of S4 and S5. It seems that the difference is suddenly decreased after S4. For the future plan, we will simulate in the case of variable range of roughness and compare simulation and theory.

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Energy Distribution of Air-hole Waveguides with Dielectric Cylinder Outside of the Defect Layer

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Light or electromagnetic waves within a certain wavelength band are confined a relatively small region, cannot be propagated in a particular direction. A photonic crystal such as optical nano periodic structure is well known as optical device for controlling the propagation of light by interaction of both the wave nature of light and periodicity. In particular, guiding problems of electromagnetic waves are very interesting in many areas of physics and engineering. In order to understand the properties of the periodic structure waveguide, it is necessary to examine the photonic band gaps or stop-pass band regions. But, numerical results of propagation properties are not indicated in detailed. And also, in the numerical analysis of photonic crystals waveguide, it is employed the FDTD method[1], FEM method based on the variational method[2], and another numerical techniques[3].

In previous paper[4], we have analyzed the periodically dielectric waveguides with different radius composed of dielectric circular cylinders array with air-hole cylinder, and investigated the influence of complex propagation constants at the first stop band region and distribution of energy density in the defect area and by using the combination of improved Fourier series expansion method and multilayer method for TE mode.

In this paper, we analyze the energy distribution of air-hole waveguide with dielectric cylinder outside of the defects layer as shown in Fig.1. Consequently, the aim of this paper is to obtain optimum dielectric waveguide structure to concentrate the energy into the defect area for TE and TM mode. Numerical results indicate for the complex propagation constants at the first stop band region and the energy density for TE mode compared with previous dielectric waveguide structures[4].

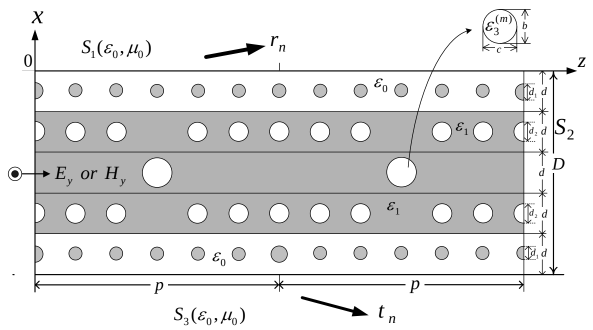

Figure 1. Structure and coordinate system of air-hole waveguides with dielectric cylinder outside of the defects layer

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Wiener-Hopf Analysis of the Plane Wave Diffraction by a Thin Material Strip

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The analysis of the scattering by material strips is an important subject in electromagnetic theory and radar cross section (RCS) studies. Volakis (Volakis, J. L., Radio Sci., Vol. 23, pp. 450-462, 1988) analyzed the diffraction problem involving a thin material strip using the dual integral equation approach and the extended spectral ray method together with approximate boundary conditions. Volakis has obtained a high-frequency asymptotic solution to the original strip problem by superposing the diffracted fields from the two independent material half-planes and the doubly/triply diffracted fields between the edges of the two half-planes. Therefore, his analysis may not be applicable unless the strip width is large compared with the wavelength. In this paper, we shall consider the same strip geometry as in the paper by Volakis, and analyze the H-polarized plane wave diffraction using the Wiener-Hopf technique together with approximate boundary conditions.

The geometry of the material strip is shown in Figure 1, where ε_r and μ_r denote the relative permittivity and the relative permeability of the material, respectively, and ϕ^i is the incident field of H polarization. Introducing the Fourier transform of the scattered field and applying approximate boundary conditions in the transform domain, the problem is formulated in terms of the simultaneous Wiener-Hopf equations, which are solved exactly via the factorization and decomposition procedure. However, the solution is formal in the sense that infinite branch-cut integrals with unknown integrands are contained. By using a rigorous asymptotic method together with a new special function defined in this paper, we shall derive a high-frequency solution of the Wiener-Hopf equations, which is expressed in terms of an infinite asymptotic series. Our solution is valid for the strip width greater than about the incident wavelength and accounts for all the higher order multiple diffraction effects rigorously. The scattered field is evaluated asymptotically by taking the inverse Fourier transform and applying the saddle point method. It is to be noted that our final solution is uniformly valid for incidence and observation angles. Numerical examples of the RCS are presented for various physical parameters and far field scattering characteristics of the strip are discussed in detail. Some comparisons with Volakis are also provided.

Acknowledgment
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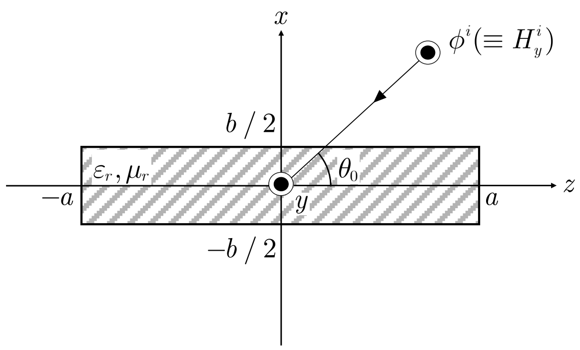

Figure 1. Geometry of the problem.

Maxwell-Schrödinger Hybrid Simulation for Optically Controlling Quantum States: A Two-Level System Manipulated by a Light Pulse Pair

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Recent remarkable advancements in laser technology have enabled us to control quantum states of atoms, molecules, and quantum dots by laser pulses. This innovative technology of controlling quantum systems by external electromagnetic fields would be a promising seed for the next generation key technology in various applications of electrical and nano engineering. Pioneering efforts in this direction have been already made, aiming at, such as highly-efficient state-selective photochemical reactions, arbitrary q-bits operation in quantum computation, and so on.

From theoretical points of view dealing with such control problems boils down to the issue of designing an optimal spatiotemporal profile of the applied laser pulse (called *light control pulse* hereafter). Recent experimental studies have demonstrated that adroit modulation to the laser pulses through a liquid-crystal phase modulator driven by a genetic algorithm enables them to control product yields in certain photochemical reactions. At the same time a significant theoretical progress in the last decade has added a new dimension to the design of light control pulses, namely, designing light control pulses based on *optimal control theory*.

In the present study we have focused on a quantum two-level system of an electron confined in a quasi-one-dimensional nanostructure modelling quantum dots or nanowires, which manifests an ideal system for exploring basic q-bit operations in quantum computation. We have studied switching properties of this system manipulated by laser pulses, that is, an arbitrary and complete transfer of probability densities over the intended two quantum levels by using theoretically-designed laser pulses. Light-control pulses have been generated by our recently proposed designing method that relies on highly-accurate solutions of the coupled Maxwell-Schrödinger equations [T. Takeuchi, et al., *IEEE J. Quantum Electron.*, 50, 2014; T. Takeuchi, et al., *PIER* (*Invited paper*), 148, 2014]. The Maxwell-Schrödinger hybrid simulation has been employed here since, as we have demonstrated recently, the incident laser pulse in the vicinity of the target system can be disturbed significantly by the induced radiation from the excited electrons of the target system itself [T. Takeuchi, et al., *Phys. Rev. A*, 91, 2015]. This effect of the local modification of the incident laser fields has been thought to be negligibly small and thus has been neglected, to our best knowledge, in all previous theoretical studies.

As a demonstration we have examined control ability of the light control pulses with respect to the switching operations designed by our proposed method solving the coupled Maxwell-Schrödinger equations and by the *conventional* one [Y. Ohtsuki, et al., *J. Chem. Phys.,* 109, 1998], that solves only the time-dependent Schrödinger equation, thus neglecting the local modification of the incident laser pulses by the electron excitation. A comparison between the results employing these two distinct pulses has clearly shown that the light control pulses obtained by the conventional scheme could hardly control the system stably while does our proposed pulses thanks to incorporating the effect of this local modification. The present study suggests that our proposed scheme of designing light control pulses can be an indispensable technology for light-driven ultrafast computation.

Twin is Better Than Single: A Hybrid Localization Method Using RSS and Time of Flight

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A positioning system allows user to track their position in real-time by using the knowledge of radio frequency signal (RF). Global Positioning System (GPS) is the most widely used outdoor localization system; however, it is infeasible in indoor environment due to the rich of obstacles and multipath effect. General ranging-based localization technique that is mainly used in GPS, turns out to be difficult for applying in indoor environment because it requires a very precise timing and synchronization which is unrealistic in distributed systems. To circumvent the difficulty of time synchronization, ToF(Time of Flight) based ranging is adopted; however its accuracy depends on sampling frequency of ADCs. Another feasible Indoor Positioning System (IPS) method is RSS-based fingerprinting where location is estimated by matching Received Signal Strength (RSS) profile with the database that stored RSS fingerprints at reference locations. Again, RSS measurements are not robust and highly time-varying, causing a large error in some applications.

This work presented a new way of indoor localization by using Time-of-Flight (ToF) as well as RSS. In theory, ToF is better than RSS in term of reliability and accuracy because their temporal and spatial dynamicity are less than those of RSS. However, ToF based methods are applicable only when many LoS (Line of Sight) paths are available. Instead of using ToF as ranging information we use ToF as fingerprinting information. Also we propose to combine ToF and RSS such that the proposed methods can be applicable to indoor environments with many obstacles. We have experimented various estimation method in order to find a better solution than basic fingerprinting algorithm where accuracy is limited by a gap between fingerprinting points. We found that by using the knowledge of neighbor fingerprinting locations, it can significantly improve the accuracy. We evaluated the performance of the proposed method via simulation and experiments, and the result has shown that our work outperformed previous methods.

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Localization of Coherent Targets in a Multiple-Input Multiple-Output Radar Employing Spatial Smoothing between Virtual Antennas Extrapolated from Real Antennas

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A multiple-input multiple-output (MIMO) radar system utilizes multiple antennas for both transmission and reception. The system transmits signals that are orthogonal to each other and combines the received signals at a signal processing unit. It can localize multiple targets through joint estimation of the directions of departure and directions of arrival of the targets. The estimation is commonly based on an eigenspace-based algorithm, such as multiple signal classification (MUSIC), Capon, or estimation of signal parameters via rotational invariance techniques (ESPRIT). The $M_t \times M_r$ MIMO system, consisting of M_t transmitting and M_r receiving antennas, can localize $M_t M_r - 1$ targets, when the received signals from the targets are mutually incoherent, and thus the rank of the correlation matrix of the signals is full. When the signals are coherent, however, the rank deteriorates and the localization cannot be achieved.

This problem has been mitigated by employing a spatial smoothing technique [1], which defines subarrays from the transmitting and receiving arrays, then averages the correlation matrices among the subarrays, and recovers the rank of the matrix. The number of the simultaneous localizable targets, however, decreases to $N_t N_r - 1$, where N_t and N_r are respectively the number of subarray elements for transmission and reception.

This paper proposes an amended spatial smoothing technique. It extrapolates virtual elements outside the real transmitting and receiving arrays by estimating the arriving phase at those elements, and then averages the correlation matrices of the subarrays consisting of the real and virtual elements. Assume transmitting signals possessing (ultra) wide bandwidth yielding a high time resolution. Let $\tau_{k,m,n}$ be the echo arrival time from the *m*-th $(1 \leqq m \leqq M_t)$ transmitting element to the *n*-th $(1 \leqq n \leqq M_r)$ receiving element via *k*-th ($1 \leqq k \leqq K$) target, where *K* is the total number of the targets. The $\tau_{k,m,n}$ can be approximated by either a plane on a sphere against (m, n) for each of k, when the targets are respectively located in the far or the near distance with respect to the sizes of the transmitting and receiving arrays. The receiving phases at the virtual elements are then extrapolated from the approximated arrival times. The number of localizable targets can be maintained, even when the received signals are coherent, by spatially smoothing the subarrays clipped out from the extended arrays. The performance was evaluated through simulation: a 3×3 MIMO radar system, unable to localize five coherent targets, was extended to 5×5 and 7×7 systems, which can localize the coherent targets.

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Human Motion Classification Utilizing Radio Signal Strength in Wireless Body Area Network

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Human motion classification has been studied intensively since information of human activities is very useful for many kinds of applications such as activity monitoring, physical rehabilitation, abnormal activity detection and so forth. In wireless body area network (WBAN), human activity-related information is not only beneficial for application level, but it can also be used to design reliable communication protocol, for instance, in MAC layer. Generally, the human motion classification system has been researched using camera-embedded equipment or body-mounted sensors such as accelerometer or gyroscope. However, although we notice that human motions highly affect the characteristic of wireless channel, only few researches considered using the radio signal strength to classify human motions. Therefore, we aim to investigate whether human motions could be recognized by the pattern of received radio signal strength. The WBAN radio signal strength in several human motions was obtained from the numerical simulation using FDTD generated at 403.5 MHz [1] and 2.45 GHz [2]. The WBAN channel propagation from the simulation results was used in this research to construct the human motion classifier. The human motion classification consisted of two main stages: one was pre-processing stage; the other one was classification stage. Pre-processing stage was responsible for preparing input vector for the classification stage. Time-series of received signal levels were extracted from the simulation result. In current research, time-domain features were computed from the time-series of received signal levels. The time-domain features were then normalized and inputted to the classifier. The classifier was trained by four different algorithms, which were back propagation (BP), k-nearest neighbor (kNN), support vector machine (SVM), and decision tree (DT). 3-class classifier was constructed to classify 3 human motions including running, walking and weakly walking. 5-class classifier was constructed to classify 5 human motions including 3 motions mentioned earlier, sitting/standing and sleeping motion. The classifier was constructed individually for each particular sensor link. Performance of the classification was measured by the accuracy rate, which refers to the percentage of correct classifications and total classifications. BP and SVM performed well in this classification task with the accuracy rate of 73.9–95.7 and 75.4–93.7 percent respectively, while kNN and DT obtained slightly lower accuracy rates, which were 68.1–91.3 and 63.8–89.4 percent respectively. Among six data links, Navel-Chest (Tx-Rx) link provided the most recognizable information, which led to 90.1–93.7 percent of accuracy rate when classifier was SVM. These results suggest that the human motion classification can be employed in WBAN utilizing only the continuous radio signal strength.

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Localization of Illegal Radios Utilizing Phase-Difference as Location Fingerprints

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Illegal radios have the potential to cause harmful interference to licensed radio systems, and may be a large threat to those used by emergency services. Statistics of illegal radios by the Ministry of Internal Affairs and Communications (MIC) in Japan indicate that there is still a large number of illegal radio appearances [1], and it is crucial to localize and tackle these illegal radios to ensure security especially in large events such as the upcoming 2020 Tokyo Olympics.

Conventional localization techniques utilizing angle of arrival (AOA) and received signal strength (RSS) suffer from low accuracy in dense urban environments due to a large number of multipaths and the lack of line-of-sight (LOS) between the target and Rx sensors. Fingerprint-based techniques have been proposed to utilize the richness of information contained in the multipaths [2], but generally they require knowledge of the target's signal parameters when collecting fingerprints in the training phase. To solve the abovementioned problem, [3] proposed a fingerprint-based localization technique using the cross-correlation of channel impulse responses (CIR) as location fingerprints, and these fingerprints are interpolated in bandwidth, frequency and spatial domains. However, they only utilized the magnitude of fingerprints while the phase information was discarded.

In this paper, the original framework proposed in [3] is employed, and a novel technique which utilizes phase difference between elements of an antenna array as location fingerprints is proposed. In order to perform frequency domain interpolation of location fingerprints, an AOA estimation technique utilizing data from several frequency bands simultaneously is proposed. The location of the illegal radio is estimated by performing pattern matching between the training fingerprints and the actual illegal radio's fingerprints based on the minimum squared error criterion. The accuracy of the proposed algorithm was evaluated through ray-tracing simulations using a 3-D model of the urban area surrounding Shinjuku station, Tokyo. Results show that the proposed algorithm is comparable with results in the previous literature, and a hybrid algorithm is expected to achieve a greater improvement in localization accuracy.

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Resonant Tunneling Diode Receivers for 300-GHz-band Wireless Communications

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Resonant Tunneling Diodes (RTDs) are promising devices for terahertz (THz) wireless communication systems not only for a transmitter as an oscillator but also for a receiver as a detector [1]. There have so far been several reports on the increase of the data rate with respect to the modulation bandwidth [2] and antenna bandwidth [3]. As for the receiver using RTDs, the highest data rate is 13 Gbps [4]. One of the bottlenecks which determine the receiver bandwidth is a baseband (BB) circuit after the demodulation. In this paper, we propose a technique to enhance the bandwidth of the BB circuit and demonstrate an error-free (bit error rate < 10^{-11}) transmission at a data rate up to 17 Gbps using the RTD receiver at 300-GHz band.

We examined two types of BB circuits as shown in Figure 1, which are connected with the RTD chip [3, 4] by bonding wires. One BB circuit (type A) consists of a coplanar strip line (CPS), a grounded coplanar waveguide (GCPW) with via holes and a SMA connector as shown in Figure 1-(a). The CPS-GCPW transition causes an impedance mismatch, which limits the available 3dB-bandwidth to 8 GHz, as shown in Fig. 2-(a). The other one (type B) shown in Figure 1-(b) is only constructed from a tapered coplanar waveguide (CPW) and a SMA connector. The tapered structure ensures the impedance matching. In addition, two ground conductors of the CPW are connected at the end. The 3dB-bandwidths are 8 GHz and 11 GHz for type A and type B, respectively.

We performed a wireless transmission experiment using the RTD receiver with a type B circuit, together with a photonics-based transmitter [5]. The carrier frequency and the transmission distance were set to be 297 GHz and 30 mm, respectively. Figure 2-(b) shows an eye diagram at a data rate of 17 Gbps, and an error-free transmission was also confirmed by the bit error rate tester.

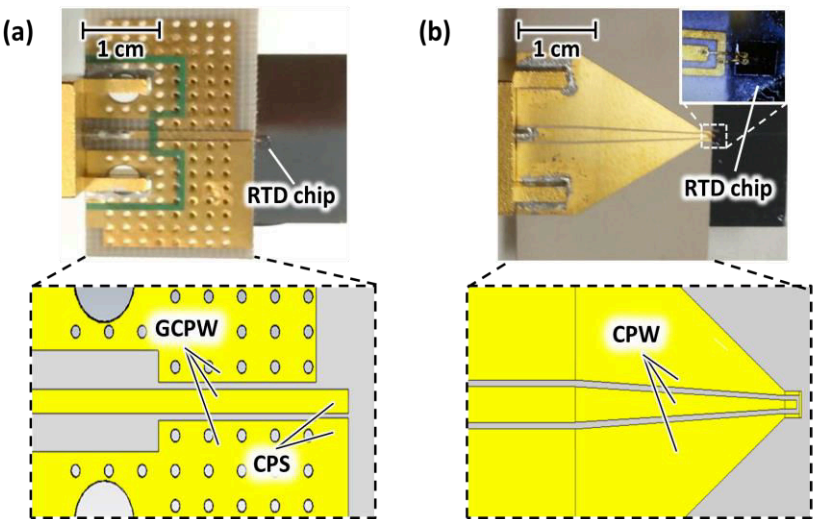

Fig. 1 Pictures and schematics of BB circuits. **(a)** Type A, **(b)** Type B

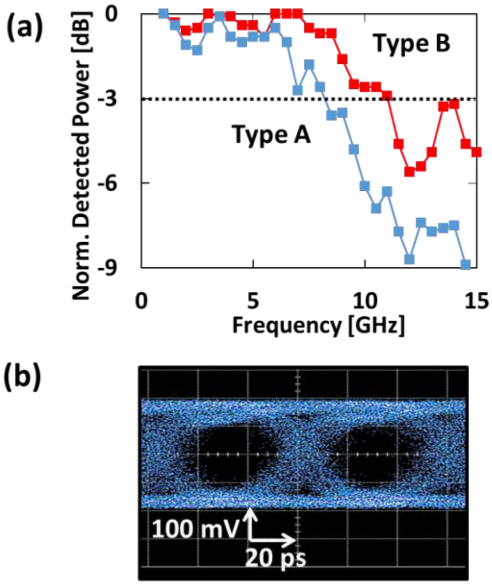

Fig. 2 (a) Frequency dependence of detected power. (b) Eye diagram

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Study on Hybrid RAN Using RoF and RoR for Distributed Small Cell Configurations

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Wireless access traffic is rapidly increasing to access variety cloud services, and the access methods diversify in various types of radio air interfaces, 3.5G, 3.9G, and 4G and future 5G, or commercial / private WLAN. Moreover, as IoT will be spread, various wireless sensor networks will be involved in increasing air interface diversification and the traffic with various types of QoS. This trend requires the more and more efficient use of radio frequency, and the size reduction of radio cell offering heterogeneous wireless access services. An effective solution will be small cell architecture, however, front-haul networks for a large number of small cells become important in their cost, construction easiness, universality for various types of air interfaces. Then, Hybrid RAN (radio access networks) using RoF (Radio over Fiber) and RoR (Radio on Radio) are effective to realize such front-haul networks.

RoF applied for WDM-PON optical access network has been widely studied [1] as a next generation mobile backhaul because of its high capacity, low transmission loss and easy construction of a large number of RBSs. As a broadband and universal front-haul network, we have proposed Radio over Fiber Distributed Antenna System in WDM-PON [2]. When implementing DAS on the WDM-PON architecture as shown in figure 1, RoF technologies enable the efficient and economical antenna distribution for several different types of MIMO RF signals. Some evaluation results in the capacity achieved by the system will be presented.

The transparency of the front-haul networks can be also realized by RoR (Radio on Radio) networks [3, 4], which can provide a free space for heterogeneous wireless services in millimeter-wave radio. Figure 2 illustrates the configuration of the proposed cascaded RoF and Digital MMW RoR front-haul networks for small cells. RoR using millimeter-wave has a potential broadband to transport microwave signals keeping their signal formats and a distributing ability to some small cells. To combat against lower transmission quality of MMW RoR compared with RoF, we employ digital MMW RoR link cascaded with RoF to expect FEC effect. In Fig. 2, point-to-point MMW RoR is shown, but RoR can be easily extended to P-MP system. Some basic experimental results in link design and signal quality will be presented.

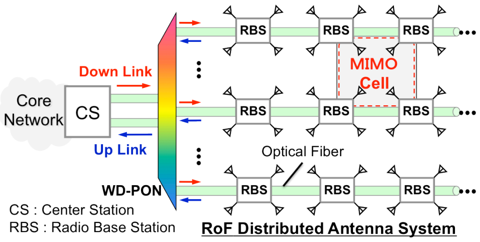

Fig 1: RoF distributed antenna system.

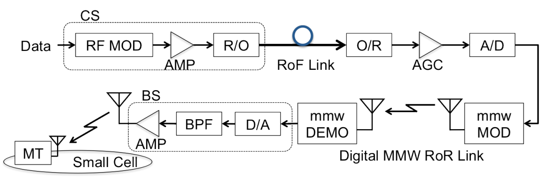

Fig 2: Cascaded RoF and digital MMW RoR front-haul.

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Terahertz Wireless Transmission Enabled by Photonics Using Binary Phase-shift Keying at 300 GHz

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Recently, there has been a growing interest in the application of terahertz (THz) waves (0.1 THz~10 THz) to ultra-fast wireless communications [1]. This paper presents the first real-time wireless transmission at 300 GHz using a binary phase-shift keying (BPSK) modulation. A coherent transmitter based on photonics has enabled an error-free (bit error rate: BER < 10^{-11}) transmission at a record data rate of 40 Gbit/s.

Figure 1 shows the schematic diagram of wireless coherent transmission based on BPSK modulation. In the transmitter, we proposed a new approach to actively stabilizing the phase of carrier signals by using the optical frequency comb (OFC) [2]. Two optical sub-carrier signals at different frequencies are extracted from the OFC using an optical filter, and combined with an optical coupler (OC). The phase fluctuations of optical sub-carriers in the optical fibers between the optical filter and the OC is stabilized by locking the phases of the two optical sub-carriers to those of the OFC signals by negative feedback for phase shifters (PS). The phase stabilized optical sub-carriers are input to the photodiode to generate the THz waves at 330 GHz which corresponds to the difference between two optical sub-carriers. In the receiver, the sub-harmonic mixer demodulated the THz waves by mixing it with the local oscillator (LO) signal, and output the recovered data signal.

Figure 2 shows BER characteristics at 40 and 45 Gbit/s and an eye diagram at 40 Gbit/s. The error-free condition was confirmed at 40 Gbit/s, when the transmitter power was -21 dBm. When we increased the data rate to 45 Gbit/s, the BER was 1.6×10^{-6}. The main reason of the BER deterioration at 45 Gbit/s is the band-limitation of the electro-optic modulator (EOM, electrooptic bandwidth of 25 GHz).

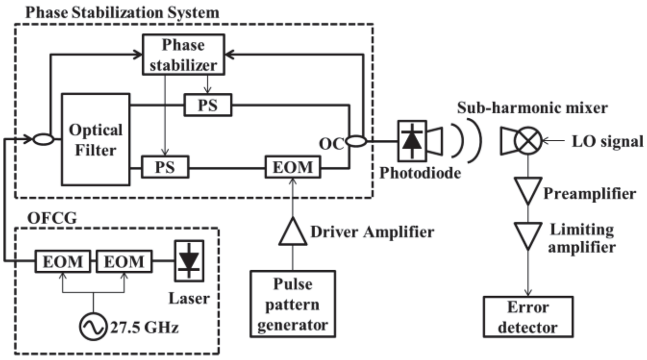

Figure 1. Schematic diagram of experimental setup for a wireless coherent transmission based on BPSK modulation.

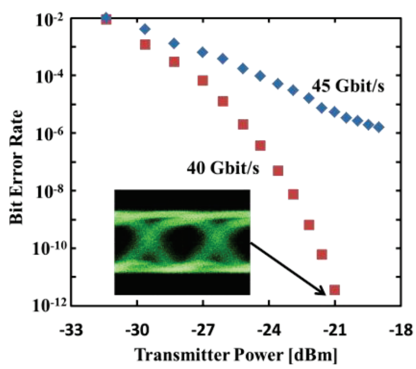

Figure 2. BER characteristic at 40 and 45 Gbit/s and an Eye diagram at 40 Gbit/s.

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Electromagnetic Imaging and Monitoring of Active Volcanoes: a Case Study and Future EM Monitoring Plan for Mt. Kusatsu-Shirane Volcano, Japan

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Diagnostic understanding of active volcanoes is one of the targets of strong social demands, as indicated by the recent phreatic eruption of Ontake volcano on 27 September 2014 and also by many other volcanic activities in Japanese Islands. Kusatsu-Shirane Volcano, in particular, is the most important target for the volcanologists at Tokyo Institute of Technology, and we have been maintaining the volcano observatory since 1986.

In the last decade, we have had successfully imaged the edifice of the volcano in three dimensions with 200m horizontal resolutions to a depth of 2km by measuring impedances using natural electromagnetic fields in the frequency range between 0.1Hz and 10kHz (Nurhasan 2006; Nurhasan et al 2006). We have found that the peak of the volcano has a bell-shaped electrical conductor, consisting of clay minerals (smectite), which works as an impermeable cap to trap underlying vapor and fluids. The micro-seismic hypocenters of the volcano are consistently located under the bell-shape conductor. The pressure source location for the recent expansion of the volcanic edifice since March 2014, is also located within the bell-shaped conductor. We think that the increase in the resistivity under the clay cap and the breakdown of the bell-shaped cap itself will lead to a phreatic eruption.

The continuous igaming of the cap structure by the electromagnetic method will thus be a key to successfully monitor the potential phreatic eruption. We now propose a controlled source electromagnetic imaging and monitoring system, consisting of multiple current loops sources and magnetic impedance (MI) sensor receiver arrays to be installed around the peak of Kusatsu-Shirane volcano.
Following the concept of ACROSS (Accurately Controlled Routinely Operated Signal System) (Kumazawa and Takei 1994), transmitting signals consist of frequency combs and receiving the signal by a large number of stacking will enable detections of small magnetic signals and their temporal changes originating from the deep geothermal system prior to future phreatic eruptions.

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Development of Upgrade BOLT System for Improvement of Location Accuracy

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As is well known, the lightning discharge process produces strong impulsive radiation, with a strong broadband spectrum. Observation sensors for lightning discharges sense electromagnetic waves, mainly in the ELF to UHF range, and especially in the LF and VHF bands. VHF band sensor sensors can observe lightning discharge process in detail but its observation coverage is limited in about 20 km. On the other hand, LF band sensor can observe lightning at much great distances in about several hundred kilometers. The scale of a thunderstorm is about several tens of kilometers maximally. Therefore, LF sensors are useful to observe lightning throughout a thunderstorm's life cycle.

Our research group has been developing the Broadband Observation network for Lightning and Thunderstorm (BOLT), which locates radiation sources associated with lightning discharges in three spatial dimensions[1]. BOLT consists of 11 LF band sensors which detect lightning pulses wide frequency range from 5 kHz to 500 kHz. We have been operating BOLT in Kansai area of Japan, locating both cloud-to-ground and intracloud discharges. Currently, the BOLT system observes about 100 to 1000 lightning pulses per a flash, but we are striving to improve both the detection efficiency and the location accuracy. Figure 1 shows an example of the lightning location results using BOLT system on 28 Jul., 2015. The white circle indicates the position of the sensor site. The plus sign is the position of the detected lightning discharges.

In order to improve the location accuracy of the BOLT system, preliminary investigation show that the number of sources located, increases dramatically when only the highest portion of the BLOT frequency band is used far location. So, our research group has proposed improving a new "DDT" antenna sensor design to improve the high frequency sensitivity of the antenna. The DDT antenna consists of a modified charge amplifier circuit. In this research, we will show the observational results with the BOLT system and discuss the advantages of the proposed DDT antenna.

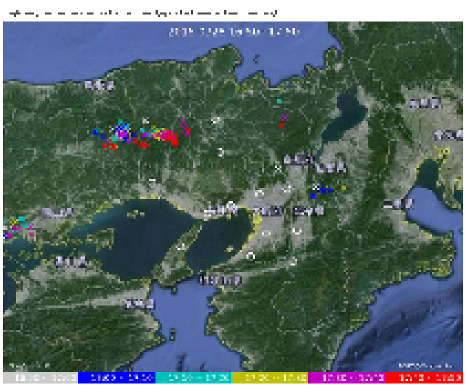

Figure 1. Lightning location mapping by BOLT system.

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Atmosphere and ionosphere connection as revealed by the network observation of Very Low Frequency radio signals

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In this paper, we reported short term to long term connection between the atmosphere and lower ionosphere using the Very Low Frequency (VLF) radio signals observed at several receiving stations within Japan. These VLF receivers are part of the UEC's VLF/LF observation network and continuously measure the amplitude and phase of narrow band VLF signals from the distant transmitters around the globe. Measurements of VLF signals allow us to track the changes occurred in the Upper-Mesosphere and Lower Ionosphere (UMLI) region as the VLF waves reflected back from this region while propagating a long distance within the earth-ionosphere waveguide. To investigate the long term relationship between the lower atmosphere and UMLI region, we compared the amplitude of VLF signals with the atmospheric parameters such as Total Column Ozone (TCO) density and stratospheric temperature at various heights for the first time for three different latitudinal regions. We show that the VLF amplitude is strongly correlated with the TCO density, stratospheric temperatures for mid-latitude propagation paths throughout the years. For high and low latitude regions, this correlation between the VLF amplitude and atmospheric parameters is small and not significant. This study indicates the experimental observation of latitudinal dependence of atmospheric influence on the upper mesosphere.

We also analyzed the VLF signals corresponding to a major Sudden Stratospheric Warming (SSW) event occurred in 2009 to investigate the short term atmosphere and ionosphere connection. As a result, we found the effect of the SSW event on the VLF signals in mid-latitude and high-latitude propagation paths. We found an enhancement of the nighttime VLF amplitude during the SSW event for all propagation paths. The strength of quasi 16-day planetary waves was also increased during the SSW event consistent with stratospheric temperature enhancement.

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A statistical study of sub-ionospheric VLF signal anomaly due to geomagnetic storms

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We investigate quantitatively the effect of geomagnetic storms on the sub-ionospheric VLF/LF propagations for different latitudes based on 2-years nighttime data from VLF/LF observation network operated by the group of the University of Electro-Communications. Three statistical parameters such as average signal amplitude, variability of the signal amplitude, and nighttime fluctuation were calculated daily during two years for 16~21 independent VLF/LF transmitter – receiver propagation paths consisting of 3 transmitters and 7 receiving stations. These propagation paths are suitable to simultaneously study high latitude, low-mid latitude and mid-latitude D/E-region ionospheric properties. We found that these three statistical parameters indicate significant anomalies exceeding at least 2 times of their standard deviation from mean value during the geomagnetic storm time period in the high-latitude paths with an occurrence rate of anomaly between 40 and 50 % presumably due to the auroral energetic electron precipitation. The mid-latitude and low-mid latitude paths have smaller influence from the geomagnetic activity because of smaller occurrence rate of anomalies even during the geomagnetically active time period (from 20 to 30 %). The anomalies except geomagnetic storm periods may be caused by atmospheric and/or lithospheric origins. The obtained statistical occurrence rates of ionospheric anomalies for different latitudinal paths during geomagnetic storm and non-storm time periods are basic and important information not only to identify the space weather effects toward the lower ionosphere depending on the latitudes but also to separate various external physical causes of lower ionospheric disturbances.

Statistical Spatial Distributions of Lightning with Charge Moment Changes Over Northern Area of Japan by ELF and LLS Observations

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Electrical characteristics of Cloud to Ground Flashes (CGFs) over northern area of mainland Japan were investigated by focusing on the information of Charge Moment Changes (CMCs). Peak current (Ip), polarity information and lightning geolocation were detected from the conventional lightning location system (LLS), while corresponding lightning CMCs were calculated by using transient electromagnetic radiations in the Extremely Low Frequency (ELF) range so-called ELF transients observed by the group of the University of Elecro-Communications (UEC) in Moshiri, Hokkaido, Japan. Statistical spatial distributions of CGFs with their CMCs and peak currents were obtained. In this work, we analyzed the lightning data from three successive years from the summer of 2011 to the end of 2014 including several data gaps in the ELF data due to the system failure and/or electrical power cut. Therefore practical number of days for the data analysis is about 800. Remarkable difference between CMCs and Ip was found in the spatial distributions of CGFs. Negative CGs with a large CMCs were inferior to those for +CGs and were mainly distributed over inland regions. This tendency represents characteristics of lightning activity during the summer thunderstorm activity in Japan. On the contrary, the number of positives with a large CMC was small and seen over the Sea of Japan and along the Hokuriku coast, where winter lightning with a large positive CMC are expected [1]. Negative CGFs with a large Ip were distributed more over the coastal areas and the Pacific and Sea of Japan, but positives were observed mostly over the Sea of Japan. These statistical distributions provide the basic information of not only about the lightning physics but also to prevent/mitigate potential damages to the power grid systems and reusable power generating systems because CGFs with a large amount of charge amount play a critical role on incidents to these systems.

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Modeling and possible determination of D-region ionospheric perturbation during annular solar eclipse on May 21, 2012, from VLF signal simulation and multi-propagation path observation from UEC-VLF network: preliminary results

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A major part of the path of the annular solar eclipse of May 21, 2012 (magnitude 0.9439) was over southern Japan. The D-region ionospheric changes associated with that eclipse, led to several degree of observable perturbations of sub-ionospheric very low frequency (VLF) radio signal. The University of Electro-Communications (UEC) operated VLF network is distributed over Japan and the eclipse associated perturbations were recorded in several receiving stations (R_x) simultaneously for the VLF signals coming from NWC/19.8kHz, JJI/22.2kHz, JJY/40.0kHz, NLK/24.8kHz and other VLF transmitters (T_x). The objective of this work is to locate and quantify the amount of lower ionospheric perturbation from observed VLF signal changes during eclipse. Inui and Hobara (2014) has already analyzed the same event using 2D-Finite Difference Time Domain (FDTD) method and reproduced most of the observed VLF signal deviations. For simulation, they used same set of signal propagation path parameters for all paths. We include respective parameters like ground conductivity map, anisotropic ionosphere for different propagation paths from well known Long Wave Propagation Capability (LWPC) code. In this work, we considered the 2-parameter exponential D-region ionospheric model and assumed a generalized space-time dependent 2-dimensional elliptical Gaussian distribution type model perturbation for ionospheric parameters, such as, effective reflection height (h') and sharpness factor (β). The depth ($\triangle h_{max}$, $\triangle\ \beta_{max}$) and half widths ($\sigma_{\theta,\phi}$) of that Gaussian distribution are being used as optimizing simulation parameters, keeping consistency with real eclipse shadow pattern. In the vicinity of the eclipse zone, for VLF amplitude and phase simulation over several signal propagation paths of UEC-VLF network, we used the LWPC code as a tool (Pal et al. 2012). Results have both similarities and dissimilarities with actual observed signal perturbations according to the limitations of the model. Based on it, a preliminary model for determination of spatial scale and degree of lower ionospheric perturbation has been proposed. Hence, the initial simulation results are presented here (Basak and Hobara, 2015).

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Bulk Current Injection Simulation Using Integrated Circuit Immunity Macro Model

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As automotive semiconductors and electronic products have increased, electromagnetic susceptibility has become more important for integrated circuit (IC) reliability in terms of safety. For conducted immunity, the bulk current injection (BCI) method is widely used for testing automotive components. The difficulty of predicting the results of BCI tests causes a long term development of automotive components. Hence, a prediction method for BCI test such as numerical simulation is highly desired. This paper provides a new simulation method for BCI tests. Injected RF disturbance that reaches to an integrated circuit (IC) is calculated by electromagnetic analysis with a high accuracy injection probe model [1]. In order to define the failure criterion, the direct power injection (DPI) based IC immunity macro model for conducted immunity (ICIM-CI [2]) is adopted.

The DUT is an automotive IC chip which has a pair of power supply terminals (Vcc, Gnd) and one analog output terminal (Vout). DPI tests are performed in order to determine the voltage criteria of failure (Vout voltage offset larger than 50 mV). Figure 1 shows the BCI setup which is simulated by electromagnetic analysis. The IC is mounted on the EUT. The RF disturbance voltage injected by BCI method is calculated and compared with the voltage criteria of failure. Figure 2 shows the calculated and simulated results. If the RF disturbance voltage at the terminal exceeds the voltage criteria of failure, the BCI test result is judged as failure in the simulation. The experimental failures at 120 MHz, 200 MHz, 270 MHz and 300-350 MHz are well reproduced in the simulation. The results indicated that the proposed method has the possibility to predict BCI test results.

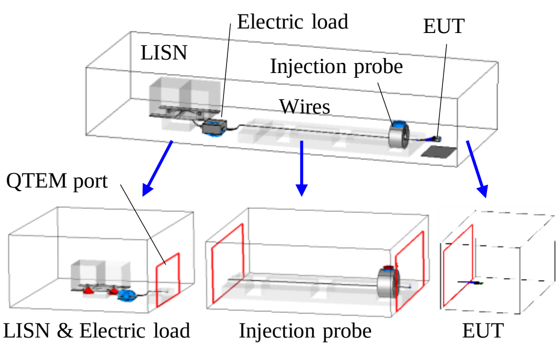
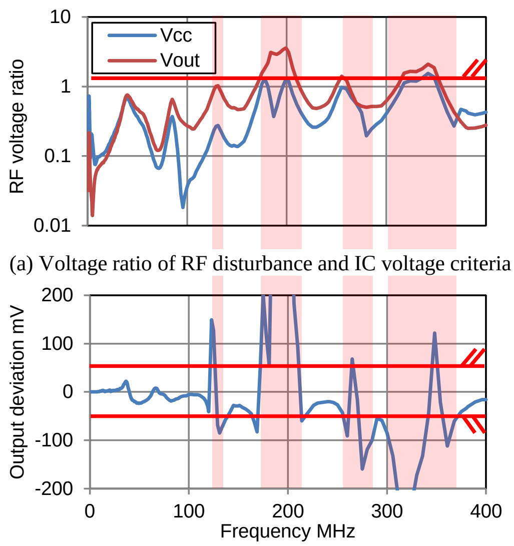


Figure.1 BCI simulation model



(a) Voltage ratio of RF disturbance and IC voltage criteria

(b) Measured DC Vout voltage deviation

Figure 2. Results of BCI Simulation and experiment.

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Estimation of Packet Error Rate Considering Pulse Duration of Burst Disturbance

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As one of the evaluation indexes of electromagnetic disturbances, the amplitude probability distribution (APD) has been specified in CISPR 16-1-1. In some previous researches, the estimation methods of the impact on communication quality from APD of disturbances were proposed on the assumption that each bit error occurs independently [1, 2]. However, these estimation methods cannot come into effect for continuous burst disturbances because the assumption of independent bit error does not hold good. Moreover, the data is transferred not by bits but by a packet in IP-based communication networks.

We have studied the impacts on packet error rate (PER) of a direct-sequence spread-spectrum (DSSS) system by burst disturbances, and we propose the estimation method of PER considering the collision probability between a packet and a burst disturbance with various pulse durations

To simplify the relationship between PER and pulse duration, the model with constant transmission period $\boldsymbol{T}_{\mathbf{p}}$, constant packet length $\boldsymbol{M}$, and constant transmission time of a packet $\boldsymbol{T}_{\mathbf{s}}$ is considered as shown in Fig. 1. Assuming that the duration in which the amplitude of $\boldsymbol{K}$-th burst disturbance is greater than the level $\boldsymbol{X}$ is $\boldsymbol{T}_{\mathbf{d,k}}$, the PER $\boldsymbol{P}_{\mathbf{PER}}$ can be estimated by $\boldsymbol{T}_{\mathbf{s}}$, $\boldsymbol{T}_{\mathbf{d,k}}$, and measurement time $\boldsymbol{T}_{\mathbf{all}}$.

$$P_{\mathrm{PER}} = \frac{\Sigma_k (T_{\mathrm{s}} + T_{\mathrm{d,k}})}{T_{\mathrm{all}}} \qquad (1)$$

Meanwhile, the APD $\boldsymbol{P}_{\mathbf{APD}}$ is the fraction of time that the disturbance amplitude is greater than the level $\boldsymbol{X}$.

$$P_{\mathrm{APD}} = \frac{\Sigma_k T_{\mathrm{d,k}}}{T_{\mathrm{all}}} \qquad (2)$$

Figure 2 indicates the measurement system to confirm the availability of our estimation, and Figure 3 compares the estimated results by proposed method and from APD. The estimated result by proposed method agrees with measured one, and the difference in PER between our proposal and APD is $\boldsymbol{T}_{\mathbf{s}}$ just as shown in the difference between Eqs. (1) and (2).

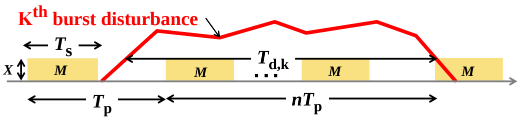

Figure 1. Communication model.

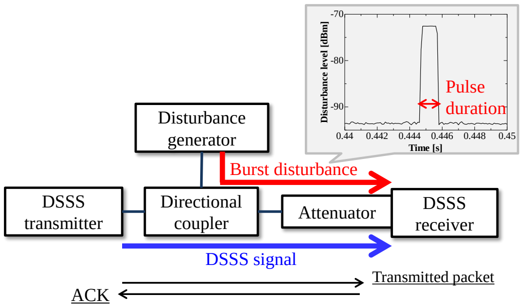

Figure 2. PER measurement system.

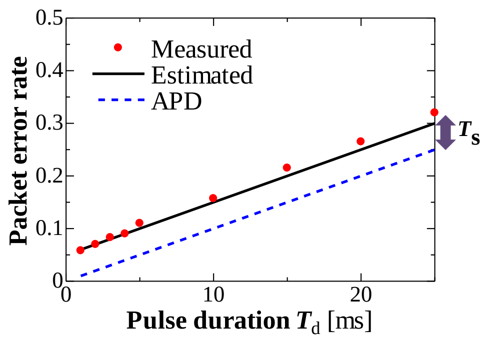

Figure 3. Measured and Estimated PER for various pulse durations.

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Wideband Characterization of Multilayer Wave Absorber Using FDTD Method

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Most of absorbing materials are the frequency dispersive materials which can be effectively modeled by the Finite-Difference Time-Domain (FDTD) method. To facilitate the FDTD simulation for the wideband response, the appropriate parametric model of material as the function of frequency is utilized. In previous work [1], the frequency characteristic of the absorbing material made of foamed polystyrene was approximated by the multiple poles Debye model. To widen the absorption bandwidth, the multilayer absorbers are frequently used. However, their performance depends on the combination of thickness and electrical properties (permittivity and/or permeability) of the material in each layer. In this paper, based on the optimum design parameters from [2], the frequency characteristic of multilayer absorbers (from one layer to eight layers) are investigated and modeled by 1D-FDTD method with various orders of Debye model for material property approximation. Figure 1 depicts the calculation model for multilayer wave absorber using 1D-FDTD technique. Each layer is characterized by thickness d_n and Debye parameters computed from carbon content G_n. A modulated Gaussian pulse is used as the pulse excitation source with a center frequency 5.2 GHz and a bandwidth 4 GHz. This pulse is injected into the simulation domain at distance $\lambda_0 = 0.75$ m from the front layer of absorber.

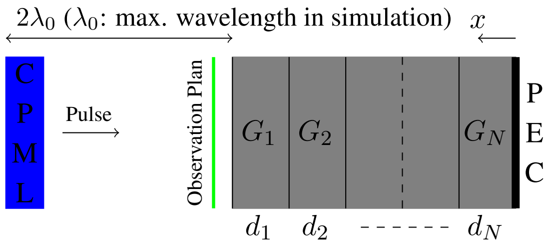

Figure 1. Calculation model for multilayer absorber using 1D-FDTD technique.

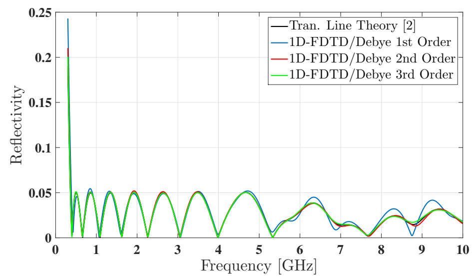

Figure 2. Reflectivity of eight-layer absorber.

The performance of absorbers is evaluated by reflection coefficient. To validate this coefficient, it is compared with one computed by transmission line theory. Figure 2 shows the reflection coefficient computed for the eight-layer wave absorber using tran. line theory and 1D-FDTD method. As a result, the reflection coefficients calculated by both methods showed good agreement, and the effectiveness of the Debye approximation by this research, which can be used in wideband FDTD simulation, is shown. For future works, 1D, 2D and 3D design of wave absorber in time domain will be taken into account.

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A Novel Prediction for Very Low Frequency Transmitter Signal Amplitude using NARX Neural Network

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In the recent three decade Very Low Frequency (VLF) waves (3-30 kHz) from powerful transmitters have been used to study and monitor the lower ionospheric conditions. The ionospheric perturbations are identified in relation with e.g. thunderstorm activity [1], in association seismic activity [2] and others. However time temporal dependence of VLF amplitude has a complicated and large daily variabilities in general due to combinations of both effects from above and below (atmospheric and crustal activities). And quantitative contributions from different external sources have not known well yet. Thus the modelling and prediction of VLF wave amplitude is an important issues to study the lower ionospheric responses from various external parameters and to also detect the anomalies from unknown parameters.

A NARX (Nonlinear Autoregressive with Exogenous Input) neural network is used as a novel method for predicting daily nighttime averaged amplitude of Very Low Frequency (VLF) transmitter signals indicating the ionospheric perturbation around the transmitter-receiver path. The NARX neural networks has a good accuracy in predicting time series data [3] and thus are more suitable for dynamic modelling [4]. The NARX model, which was built based on daily input variables of various physical parameters such as stratosphere temperature, cosmic rays and total column ozone, possessed good accuracies during the model building. The aim of the study is to model and predict daily nighttime average amplitude of VLF wave propagation from Hawaii (NPM) to Chofu (CHO) Tokyo, Japan path using the NARX neural network.

As the result, the constructed models are capable of performing accurate one step (1 day) ahead predictions with the Pearson r is 0.92 and RMSE is 2.0 dB as shown in Figure 1. Furthermore, our results indicate the feasibility and reliability of predicting lower ionospheric properties by NARX neural network approach, and provide physical inside on the responses of lower ionosphere due to various external forcings.

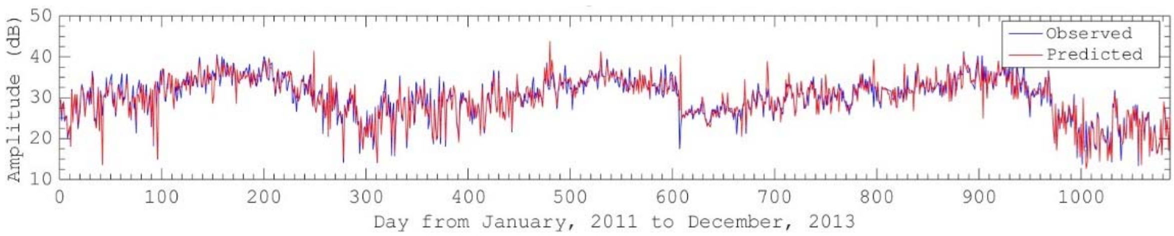

Figure 1. One Step (1 day) Ahead predictions of NARX N.N. model daily nighttime average amplitude of VLF waves NPM-CHO path over the time interval from January 2011 to December 2013 (Observed VLF-blue; OSA-red).

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Detections of Electromagnetic Pulses During and Prior to Earthquakes

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I have been observing electromagnetic (EM) waves in the earth and above the ground using sensor systems composed of tri-axial magnetic search coils and a vertical electric field antenna. One sensor system was inserted into a bore hole of 100 m in depth, and another was installed on the ground. When a big earthquake (M 6.3) occurred at 115 km distance from the EM observation site on April 13, 2013, the sensor system on the ground first detected a magnetic pulse, and 13 sec later, another magnetic pulses was detected in the borehole together with a seismic wave detected on the ground surface. This result suggests that the EM pulses were excited due to piezo-electric effect in the earth crust caused by vibration of aseismic wave, and they were radiated out of the ground surface [1].

In the further analysis of waveforms of EM pulses simultaneously detected above and under the ground surface when a seismic wave arrived at the EM observation site, the EM pulse detected above the ground showed an elliptic polarization whereas that in the earth showed a linear polarization. This result has proved that the EM pulse wave radiated from the deep earth, passing through a boundary (ground surface) of two media with different refractive indices. Based on this fact, we can regarded that the elliptically polarization of EM wave detected above the ground is the result of radiation of EM wave in the earth. Next, I proposed a hypothesis on an excitation mechanism of EM pulses in the earth. Then I proved the hypothesis by a laboratory simulation experiment on EM radiations form earth's crust.

I found an outstanding EM pulse detected above the ground at about 7 hour prior to an earthquake (M3.9) occurred at a distance of 24 km from the EM observation site(see Fig. 1), which showed elliptical polarization and contained electric field component. The waveform of its electric component was similar to that obtained by the laboratory experiment.

This kind of EM pulse could be regarded as a precursory signal of the earthquake.

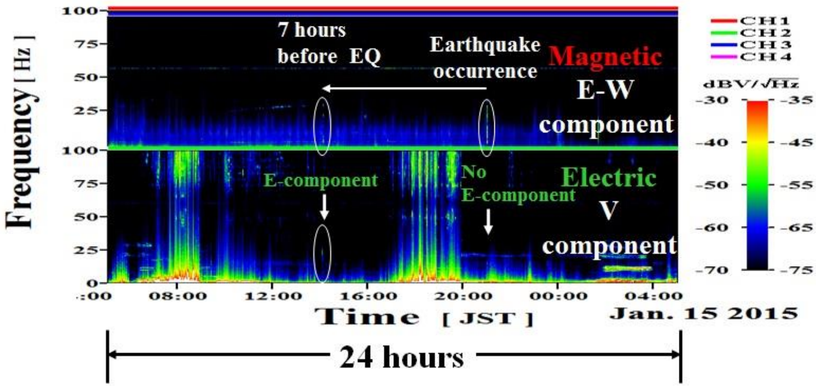

Figure 1 Spectrograms of EM pulses detected during earthquake (at 21:02) and prior to the earthquake (at 14:08) on Jan. 14, 2015.

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A Study on Rain Area Motion Along the Propagation Path and Ground Wind Velocity Around the Earth Station in Ku-Band Satellite Communications Links

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Recently, satellite communications links use frequency bands of higher than 10 GHz such as Ku band (14/12 GHZ), in addition to C band (6/4 GHz). In these higher frequency bands, however, the rain attenuation of radio waves becomes one of the severe problems of satellite communications. Thus, detailed studies on rain attenuation characteristics are necessary for reliable operations of satellite communication links, using site diversity techniques and so on. In this study, the rain attenuation characteristics of Ku-band satellite communications links are investigated from the broadcast satellite (BS) signal levels simultaneously obtained at Neyagawa campus of Osaka Electro-Communication University (Neyagawa, Osaka), as well as its Shijonawate campus (Shijonawate, Osaka) and high school (Moriguchi, Osaka)[1]. The direction and speed of rain area motions are estimated from the time differences in the attenuation detected at these three locations in light of the operations of site diversity techniques. These results are compared with the ground wind velocities observed by nearby AMeDAS stations[2] at three locations in Hirakata, Osaka, and Toyonaka cities from 2008 to 2011.

Figure 1 shows (a) the directions and speeds of rain area motion obtained from BS signal level measurements at the three locations at Neyagawa, Shijonawate, and Moriguchi, together with (b) the ground wind velocities measured at Hirakata AMeDAS station that is about 6.7 km northeast from the Neyagawa campus, respectively, in the form of circular diagrams. It is found from Fig.1 that the speeds of the rain area motions in the sky are, as a whole, several times larger than the wind speeds measured by AMeDAS on the ground. However, a considerable relationship is found between the directions of the rain area motions and ground winds, although the directions of the ground winds tend to be aligned in the northeast-southwest direction along the area of Osaka plains. Table 1 summarizes cross-correlation coefficients between the directions of the rain area motions and ground winds obtained at Hirakata, Osaka, and Toyonaka AMeDAS stations, respectively. It is found that there are still correlations that are not negligible between the directions of rain areal motions and ground winds. Thus, the AMeDAS data that is easily available in Web site seems to be hopeful to determine the direction of satellite stations when the site diversity techniques are conducted.

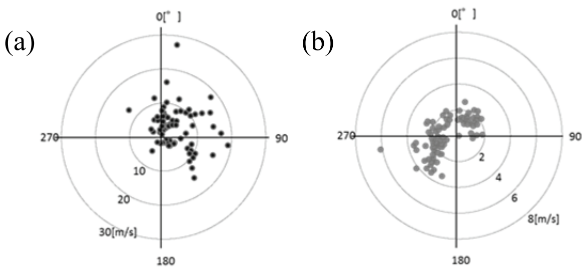

Figure 1. (a) Rain area motion and (b) ground wind velocities.

Table1. Cross-correlation coefficients between directions of rain area motion and ground winds

Hirakata	Osaka	Toyonaka
0.52	0.51	0.52

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Effects of Rain Area Motion on the Ku-Band Satellite Communications Links in Tropical Wet Season

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The effects of precipitating clouds on satellite communications links are significant as the frequency of the used radio waves becomes higher than 10GHz, especially in heavy rain areas such as Southeast Asia. Osaka Electro-Communication University conducted the rain attenuation measurements of Ku-band up- and down-link radio waves (14/12/GHz) in the tropical region, using Superbird C that connects Research Institute of Sustainable Humanosphere (RISH, Uji) and Equatorial Atmosphere Radar (EAR, West Sumatra, Indonesia) in collaboration with Kyoto University[1,2]. In this study, relationship between rain attenuation characteristics of Ku-band satellite signals and rain cloud motion is investigated in wet season of Indonesia, with aids of the X-band meteorological radar located at the EAR by the Shimane University group.

Figure 1 shows the rain attenuation of the satellite up-link (14GHz) signals measured at EAR from 12:00 to 18:00 LT on January 7, 2006. It is found that the rain attenuation as large as 4 dB is detected during about 20 min from 14:30. In this period, the horizontal display of the X-band radar echo simultaneously indicates that the core of the precipitating clouds passes over EAR at the speed of 5.73 m/s. Considering the core size of the precipitating clouds, the duration time of the rainfall at EAR is estimated to be about 15 min, being in good agreement with the duration of the rain attenuation as was shown in Fig.1.

Table 1 summarizes yearly averages of the speed of cloud motions and the duration time of the attenuation for the satellite communication links obtained during the wet season in the years of 2005 and 2006. Thus, the average duration time is found to be longer due to much slower moving speeds than those in Japan, which are typically 10-30 m/s. These characteristics seem to be carefully taken into account in design of satellite communications links in the tropical region.

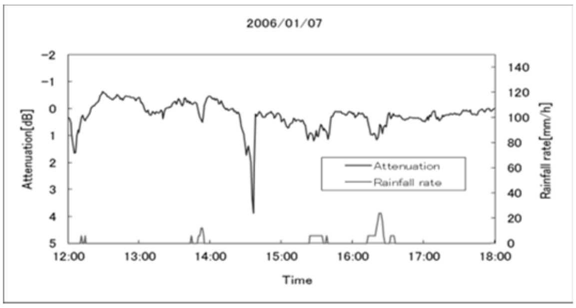

Figure 1. Rain attenuation of up-link signals.

Table 1. Yearly averages of speed of cloud motion and duration time of the attenuation.

Year	Speed [m/s]	Duration [min]
2005	4.485	39.3
2006	5.578	62.3

Acknowledgments The authors thank the Shimane University group that supplied the X-band radar data.

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Effects of Rain Area and Rain Front Velocities on Rain Attenuation Characteristics in Ku-Band Satellite Communications Links

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The recent satellite communications tend to use frequency bands of higher than 10 GHz, in addition to the traditional C band of 6/4 GHz. In these higher frequency bands, however, the rain attenuation of radio waves becomes one of the severe problems of satellite communications. Thus, detailed observations and statistical analyses of rain attenuation characteristics are necessary for reliable operations of satellite communication links, using site diversity techniques and so on. In this study, Ku-band satellite signal levels have been simultaneously observed at Osaka Electro-Communication University (OECU, Neyagawa, Osaka), the Research Institute for Sustainable Humanosphere (RISH, Uji, Kyoto) and the Shigaraki MU radar observatory (Koga, Shiga) of Kyoto University since September 2002[1]. The direction and speed of rain area motions are estimated from the time differences in the attenuation detected at these three locations in light of the effects of site diversity techniques. These results are compared with those of rain front motions inferred from the weather charts published by Japan Meteorological Agency in Web sites[2].

Figure 1 shows the motion of rain fronts extracted from the weather charts issued at 3 and 6 LT on March 30, 2007. During this period, the cold front is found to move southeastward at a speed of 21.5 m/s, with the direction of 130.8°clockwise from the north over Osaka area, as indicated by an arrow. The speed of the cold front is estimated from reduction rate of the weather chart. On the other hand, Fig.2 shows the motion of the rain area estimated from the time differences in rain attenuation occurrence among the three locations of OECU, RISH, and MU during the same period. As shown by thin and thick dashed lines that indicate the positions of the rain front inferred at RISH and MU, respectively, the rain area associated with the front is found to move southeastward at a speed of 22.9 m/s, and the direction of the motion is 123.1° clockwise from the north, being in good agreements with those estimated from the actual rain front motion in the weather chart in Fig.1. Thus, the speeds and directions of the motion of rain area that are important for site diversity operations are shown to be easily inferred from the weather charts published in Web sites, using simple image processing methods.

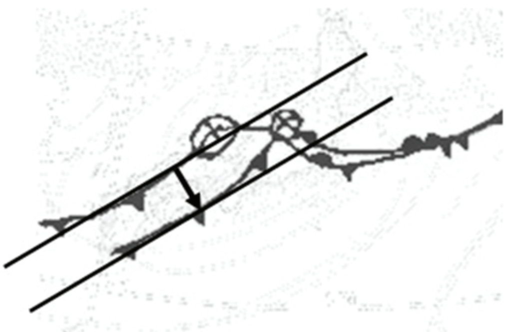

Figure 1. Rain front motion in weather charts

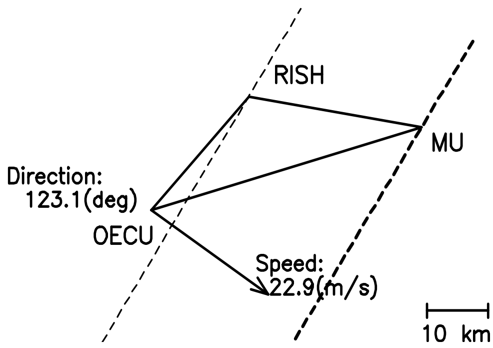

Figure 2. Rain area motion observed by three locations.

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Effects of Rain Area Motion on the Ku-Band Satellite Communications Links in Tropical Dry Season

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The effects of precipitating clouds on satellite communications links are significant as the frequency of the used radio waves becomes higher than 10GHz, especially in heavy rain areas such as Southeast Asia. Osaka Electro-Communication University conducted the rain attenuation measurements of Ku-band up- and down-link radio waves (14/12 GHz) in the tropical region, using Superbird C that connects Research Institute of Sustainable Humanosphere (RISH, Uji) and Equatorial Atmosphere Radar (EAR, West Sumatra, Indonesia) in collaboration with Kyoto University[1,2]. In this study, relationship between rain attenuation characteristics of Ku-band satellite signals and rain cloud motion is investigated in dry season of Indonesia, using of the X-band meteorological radar located at the EAR by the Shimane University group.

Figure 1 shows the rain attenuation of the up-link (14GHz) satellite signals measured at EAR from 14:00 to 21:00 LT on September 16, 2006. It is found that the rain attenuation as large as nearly 12 dB is detected during about 15 min around 17:10. In this period, the horizontal display of the X-band radar echo indicates that the core of the precipitating clouds passes over EAR at the speed of about 4 m/s. Because the core size of the precipitating clouds is about 4 km, the duration time of the rainfall at EAR is estimated to be about 17 min, being in good agreement with the duration of the rain attenuation in Fig.1.

Table 1 summarizes the average speed of cloud motions and the average duration time of the attenuation for the satellite communication links obtained in the case of the peak rainfall rates above and below 50 mm/h, respectively, during the years of 2005 and 2006. It should be noted that the duration time is still much longer in the case of peak rain fall rates larger than 50 mm/h. These characteristics seem to be carefully taken into account in design of satellite communications links in the tropical region.

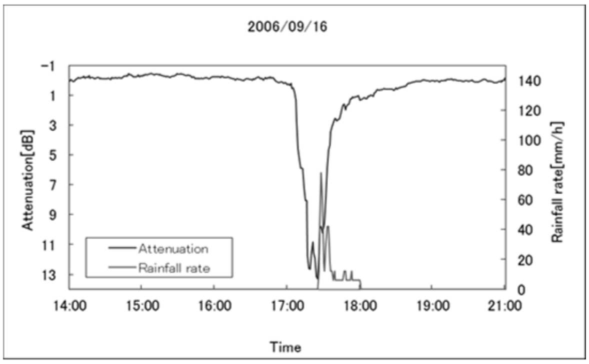

Figure 1. Rain attenuation of up-link signals.

Table 1. Yearly averages of speed of cloud motion and duration time of the attenuation.

Peak rain fall rate [mm/h]	Speed [m/s]	Duration [min]
< 50 mm/h	5.29	61.9
≧50 mm/h	4.26	70.7

Acknowledgments The authors thank the Shimane University group that supplied the X-band radar data.

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Channel Sounding in 2GHz and 60GHz Band for Multi-band Wireless LAN System

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Recent years, with the increasing demand of higher data rate, the promising millimeter wave (60GHz) band which provides a huge bandwidth (57-66GHz) is widely being investigated. Compared to low frequency signals in 2.4GHz, the millimeter wave signals are more fragile, and the typical coverage is very limited due to significantly higher propagation loss. Also, because of the smaller wavelength, 60GHz directional links are far less capable to diffract around obstacles than 2.4GHz. Hence, 60GHz signals can be easily blocked by an obstacle, such as human, and observe a high penetration loss. Because of the reasons discussed above, to combine the merits of lower frequency band such as the large coverage and the merits of higher frequency band such as the high transmission rate, the viability of multi-band wireless LAN that are capable of operating at both 2.4GHz and 60GHz bands becomes very attractive.

The multi-band channel sounding system consists of two channel sounders. For 2.4GHz band measurement, a low-cost and self-developed channel sounder which was developed based on USRP (Universal Software Radio Platform)[1] was used. We implemented the 60GHz channel sounding measurement by using a channel sounder whose details was presented in[2].

In context of his multiband wireless LAN, we implemented channel sounding measurements at both 2.4 and 60GHz with the same transceiver location in indoor environment. The comparison results show propagation path characteristics of 2.4 and 60GHz indoor radio channels to discuss their differences in terms of the diffuse scattering power and the delay spread to provide insights on a possible channel modeling strategy at the two frequencies.

By assuming that the channel impulse response is obtained under the wide-sense stationary condition where the path loss and shadowing remains constant, we rotate both the Tx and Rx antennas over 360 ° azimuth angle and acquire the channel transfer function at every azimuth angle. We derive power angular profile by the squared average of channel impulse responses obtained with the Tx and Rx antennas pointing at different azimuth angles. Figure shows the power angular profile of 2GHz band when Tx is pointing at 0 ° and Rx is pointing over 360 ° azimuth angle.

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Application of Adaptive Digital Beam Forming for Polarimetric Phased Array Weather Radar

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In 2012, we have developed a rapid scanning phased array radar and installed at the campus in the Osaka University. The phased array radar consists of the 128 antenna elements in tandem arrangements and achieves the 3-D precipitation measurements in less than 10 or 30 seconds in a range of 20 or 60 km, respectively. The phased array radar is also achieved a high density observation in elevation angles, which consists of about 100 sharped beams. Within a few years, we plan to develop a polarimetric phased array weather radar as a next generation rapid scanning weather radar, which has a dual-polarized antenna with two-dimensional circular planar phase-array elements. The polarimetric measurements has the following advantages. First, it is possible to discriminate the types of hydrometeors, which is an important step prior to rainfall estimates. Seconds, an estimation of rainfall rates not only on the ground is expected to be available, which means that a vertical structure gives insight in precipitation processes. The under development radar is capable of polarimetric measurements for the 3-D rainfall distribution in less than 10 or 30 seconds in a range of 20 or 60 km, respectively. For rapid scanning, a digital beam forming (DBF) method is used as an electronic scanning system. It is one of the main components to determine an observation accuracy of the phased array radar. This paper is focused on a DBF method for the under development radar. DBF is a signal processing method that makes a directional beam pattern. We proposed to apply minimum mean square error (MMSE) method. In [1], MMSE method is proposed as one of the adaptive digital beamforming method. The method is useful for the estimation of the distribution targets as a precipitation. The under development planar phased array antenna is based on 6992 array elements that are placed in a circular shape. We conducted a numerical simulation for precipitation measurements to evaluate an impact of a beamforming method. We compared estimation results with MMSE to those with the conventional DBF method such as Fourier beam forming (FR), to evaluate the effect on DBF. From the results, MMSE's performance was superior to DBF when comparing all polarimetric variables.

In order to evaluate the effect on the MMSE's performance, we applied the observational data using the phased array radar installed at the Osaka University. From comparison with the conventional method, the mean error is improved in the estimation results.

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Large Scale Subsurface Velocity Estimation with Array GPR System YAKUMO

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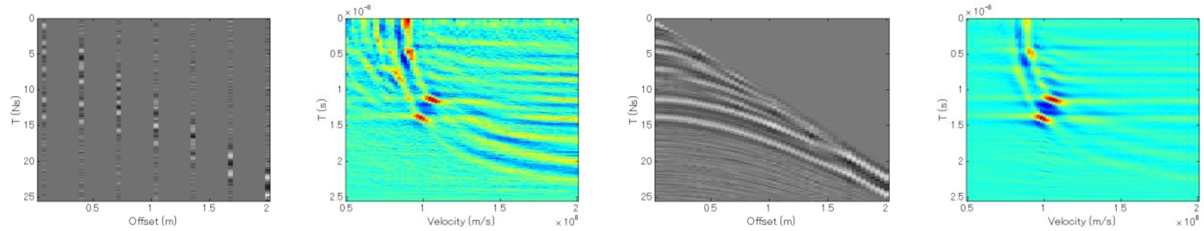
We demonstrate an approach to estimate velocity of electromagnetic wave propagation in subsurface with an array ground penetrating radar (GPR) system "YAKUMO" [1]. The common midpoint (CMP) data acquired by YAKUMO at each position can be used to estimate the velocity at different depth at that position [2]. As it shown in Figure 1(a), the CMP data acquired by the YAKUMO system only include few traces and it may introduce some artifacts to the velocity spectrum which is used to estimate the velocity, in order to estimate the velocity automatically, further processing is necessary.

In this paper, we introduced a transform based method to remove the aliasing in the CMP data, so that the irregular CMP data can be interpolated properly even there are only 8 traces are available in a CMP data. The results are shown in Figure 1(b). After the proposed processing the quality of the velocity spectrum can be enhanced. Hence the velocity profile can be generated by picking the velocity at each position automatically.



(a) (b)

Figure 1. The simulated CMP data and its velocity spectrum; (a) Raw data; (b) Reconstructed data with the proposed processing.

We also applied this approach to the data obtained at a simulated airport runway. The results are shown in Figure 2. Beside man-made voids can easily be detected, we also found that the area with velocity about 0.03 m/ns lower than surrounding areas indicates the place where man-made grooves exist. The velocity changes may be used to detect the damaged pavements.

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Enhanced Clustering of Multipath Components Utilizing Geometrical Parameters for Dynamic Indoor Double-Directional Propagation Channel

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This paper extends previously proposed clustering approach [1] which utilizes scattering points obtained from measurement-based ray tracer (MBRT) from static into dynamic double-directional propagation channel. Similar to the previously proposed approach, multipath components (MPCs) were extracted from the measurement data obtained from wideband MIMO channel sounder at 11 GHz [2] which is a future frequency band. After that, KPowerMeans algorithm (KPM) was used to group MPCs where it was extended to dynamic clustering. In this paper, two major contributions was made: 1. MBRT with angular correction was proposed to overcome the limitation of array size in channel sounding in high frequency bands by taking the physical environment into consideration and 2. KPM algorithm was extended to capture the dynamic behaviour of cluster.

Figure 1 shows the clustering results of three consecutive snapshots in an indoor environment where the Tx is moving and Rx is static. It can be observed that the algorithm can capture dynamic behaviour of clusters accurately.

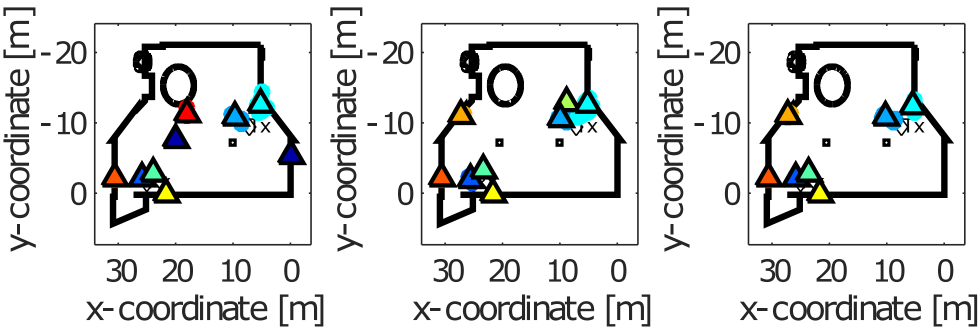

Figure 1. Clustering results of three consecutive snapshots in an indoor environment.

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Fundamental Study of GB-SAR Imaging by Compressive Sensing

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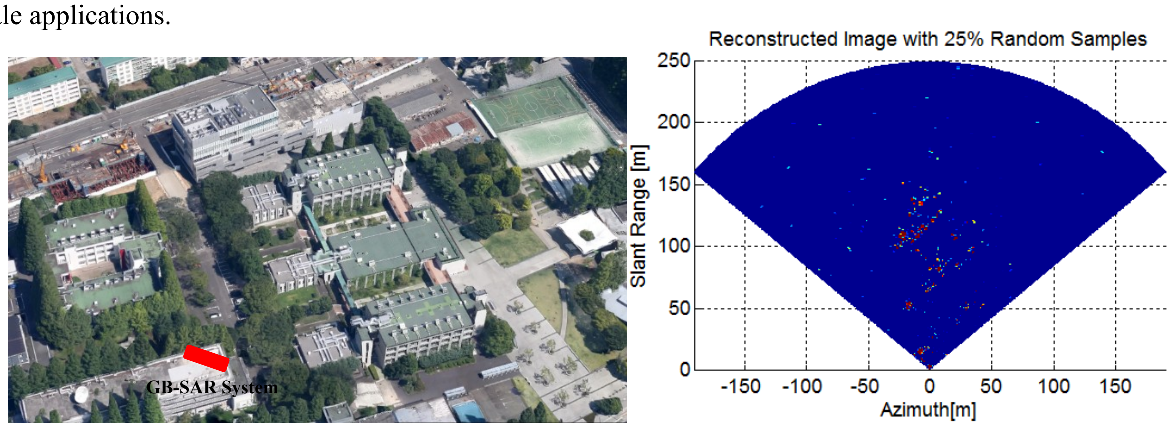
In recent years, Ground-Based Synthetic Aperture Radar (GB-SAR) has been widely applied for monitoring of landslides and infrastructures thanks to its capability of acquiring short ranges scene in just few minutes. The transmitted and received antennas are moving along a rail to synthetize a 2D image and a fixed sampling of the system bandwidth and of the azimuth dimension is performed to obtain the GB-SAR images that shows electromagnetic properties of the object. However, depending on the applications, the monitoring requirements and conditions and the system storage capabilities, a less than regular sampling of returned echos could be employed. One solution for this data acquisition problem is compressive sensing (CS). It is a recently introduced theory that permits the reconstruction of sparse signals even if a number of samples much lower than those required by the Shannon-Nyquist theorem is available.

In recent years, compressive sensing has been applied in the field of Ground Based Synthetic Aperture Radar (GB-SAR) imaging and shows great potential. The existing models are, however, based on application of the sensing matrix acquired by the exact observation functions. As a result, the corresponding reconstruction algorithms are much more time consuming than traditional focusing methods, especially in high resolution systems. In this paper, we formulate a new GB-SAR imaging model based on the use of the approximated GB-SAR observation deducted from the inverse of focusing procedures called Far-Field Pseudopolar Format Algorithm (FPFA) [1]. The proposed model forms a new compressive sensing GB-SAR imaging method that can be applied to high-quality and high-resolution imaging under sub-Nyquist rate sampling, while saving the computational cost substantially in time. In order to do this, it is necessary to use a reconstruction algorithm: spectral projected gradient (SPGL1) algorithm [2] has been employed because of its speed, transparency and guarantee of sparse recovery if the measurement matrix satisfies the restricted isometry condition. Real GB-SAR data application supports that the proposed method can perform GB-SAR imaging effectively and efficiently under Nyquist rate, especially for large scale applications.



(a) (b)

Fig.2. (a) Scene Map of North-Kawauchi Campus, Tohoku University; (b) Reconstructed image by proposed method with 25% random samples data.

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Leaf Shape Effects on the Scattering from Simplified Deciduous Leaf Structures Using Spherical Wave Harmonics

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Abstract— Leaf scatterers are a type of obstacle that is abundant in rural propagation environments. These leaf scatterers interact with propagating radio waves which may affect the performance of wireless systems operating in such environments. These leaf scatterers have complex geometries, which provide a significant challenge in modelling their electromagnetic interactions with propagating radiowaves. One common approach is to simplify the leaf structures into simpler geometries such as thin dielectric disks, cylinders and ellipsoids. In this paper, deciduous leaves are approximated as thin dielectric disks as well as thin dielectrics with realistic leaf shapes. The realistic leaf shape is approximated using a polygonal model which can estimate the leaf shape of real world leaves. The electromagnetic scattering is modelled as a T-Matrix evaluated from the least squares solution of numerical results, which describes the scattering in terms of the spherical wave harmonics. The scattered fields from similarly sized leaf shapes are evaluated from the T-matrix model and is compared with the simple disk shape approximation. It was found that the simple disk shape model underestimates the cross-polarized scattering when compared to more realistic leaf shapes.

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Experimental Evaluation of UWB Propagation in a Closed Box for Replacing Wired Interface Buses in Spacecrafts

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A use of ultra wideband (UWB) technology within spacecrafts has been proposed with a view to (partly) replacing wired interface buses with wireless connections [1]. Adoption of wireless technologies within the spacecrafts could contribute to: (i) reduction of cable weight and launching cost as a results, (ii) reduction in the cost of design, manufacture, and tests, (iii) ensuring reliable robust communication due to effect of route diversity, (iv) more flexibility in layout of spacecraft subsystems, and (v) more reliable connections at rotary, moving, and sliding joints. However, multipath propagation in semi-closed conductive enclosures, such as spacecrafts, restricts digital transmission performance. Narrowband wireless communication systems suffer flat fading in such an environment, hence need a substantial amount of fading margin, and only yield a low data rate. On the contrary, UWB is a promising technology because of its robustness against multipath propagation and low power consumption.

UWB (3.1 – 10.6 GHz, 4.2 – 4.8 GHz, and 7.4 – 7.9 GHz,) propagation and transmission were measured and characterized inside a 90-liter shield box made of stainless-steel, simulating a miniature scientific spacecraft. While the continuous wave (6.85 GHz) resulted in nearly 35-dB fading at several "dead spots" caused by multipaths, UWB practically yielded none. The UWB systems have therefore an advantage over narrowband from the viewpoint of reducing fading margins. A bandwidth over 500 MHz was capable of reducing the fading depth by approximately 3 dB in conductive semi-closed spaces like spacecraft. No discernible dependence on the distance was observed for UWB propagation gain, delay spread, or throughput, and no apparent spatial correlation between them.

The effects of inner volume, a piece of radio absorber (paneled on the inner surface), and apertures (perforated on the outer surface of satellites) on UWB propagation and link throughputs were evaluated inside the box. Increase in the inner volume of boxes resulted in higher UWB propagation gains, but wider delay spreads. Propagation gain decreased and the fluctuation range of the gain increased when increasing the area of radio absorber attached on an inner surface. On the other hand, propagation gains were almost invariable for the total area of apertures normalized by the total area of the inner surface between 0.01 and 0.1%, and gradually decreased with the area beyond 0.1%. The higher UWB propagation gains in the high-band UWB were ascribable to higher free space propagation losses. The delay spreads can be suppressed with the use of a small patch of radio absorber and/or with apertures. The throughput for low- and high-band UWB was up to 96 and 100 Mb/s, when the absorber panel covered 4 and 8% of the total inner surface area, respectively. With apertures, the throughputs were almost invariable for the normalized area of apertures between 0.05 and 0.4%, and gradually increased with the area beyond 0.4%.

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Measurement of Ionosphere Over the Western Pacific Ocean

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Recently it becomes more important to measure the ionosphere over the ocean. It is huge unobserving area for a long time and prevents the scientists from establishing precise global model of ionosphere. Now many of social requirements, e.g., international aviation glows to know the information over the ocean.

NICT has a long history of operational ionospheric observation with ionosondes since IGY 1957. On the beginning, we had four domestic observatories, Wakkanai, Akita, Kokubunji and Yamagawa. After that Akita was closed and Okinawa joined and we operate these four observatories continuously. In addition, Syowa station in Antarctica has been observing ionosphere by NICT since IGY, too. In addition as the World Data Center for ionosphere, we have a lot of number of ionospheric data obtained by foreign institutes. There are several methods to observe/estimate the ionospheric condition over the ocean; (1) oblique sounding using ionosondes, (2) trans-equatorial propagation, (3) occultation with low orbital satellites, and (4) GNSS buoy. Now we are planning to have international cooperation to establish the oblique sounding using ionosondes and trans-equatorial propagation. In addition, we are developing global simulation code named "GAIA", which calculates climate conditions from the ground to the ionosphere. In future, we plan to build data assimilation system using these simulation code and the ionospheric observation system.

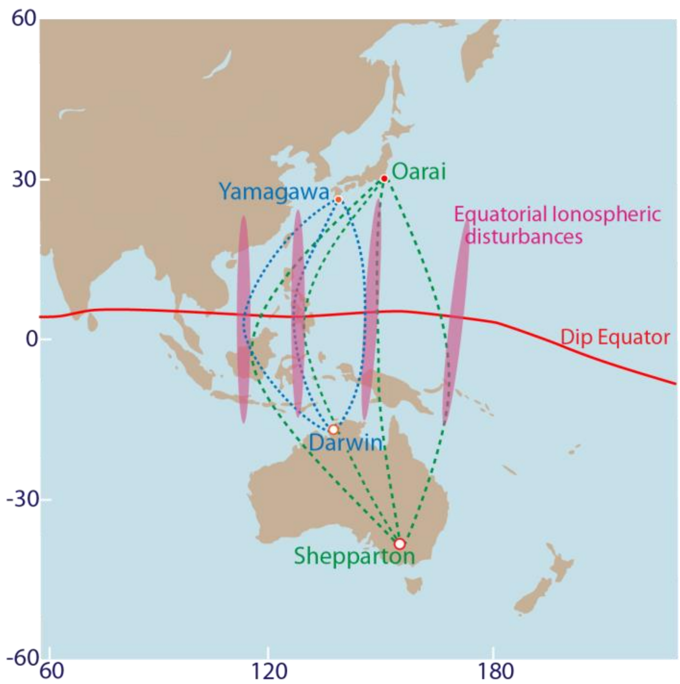

Figure 1. The image of Trans-equatorial Propagation between Australia and Japan

Ionospheric Scintillation Observations by a Digital Beacon Receiver in Tromsø

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Digital beacon receiver observations in Tromsø Norway have been conducted since October 2011. The digital beacon receiver consists of the open-source hardware called Universal Software Radio Peripheral (USRP) and the open-source software toolkit for the software defined radio (GNU Radio) [Yamamoto, 2008]. The digital beacon receiver receives radio beacon signals transmitted from Low Earth Orbit Satellites (LEOS) and enables us to measure the ionospheric total electron content (TEC) and ionospheric scintillation. We have investigated a detailed relationship between ionospheric scintillation and auroral arcs by using the digital beacon receiver and all-sky/narrow field-of-view imagers with high time resolution (1-4 Hz). Our initial results show that the ionospheric scintillation frequently occurs at the boundary of an auroral arc and in the region between auroral arcs, not in an auroral arc. The results imply that enhanced electric fields near auroral arcs may contribute to the formation of the ionospheric scintillation.

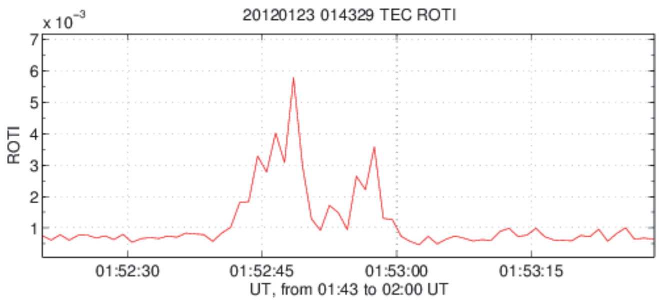

Figure 1: Time variation of ROTI (the standard deviation of the rate of change of TEC) derived from TEC data of the digital beacon receiver in Tromsø on January 23, 2012.

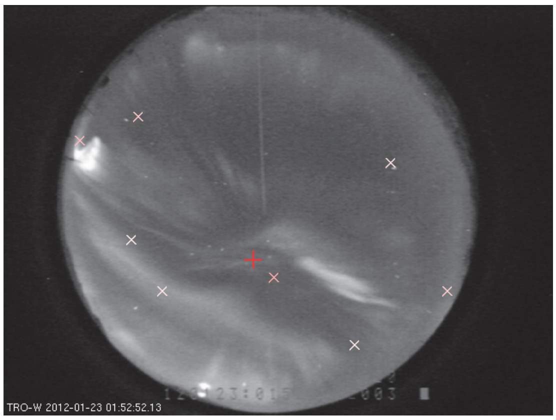

Figure 2: A selected all-sky image together with the locations of the beacon satellite (marked '+') and GPS satellites (marked '×') obtained at 01:52:52.1 UT on January 23, 2012. The ROTI increased at 01:52:48 and 01:52:52 UT when the beacon satellite was located near auroral arcs.

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Development of Digital Receiver for LF/MF Band Radio Wave Onboard Sounding Rocket

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MF absorption method is the only technique to obtain electron density profiles such as an ionospheric D region. This method estimates an electron density profile by analyzing the propagation characteristics of radio waves in the region from the ground to the lower ionosphere. The LF/MF band radio receiver is necessary for observing the broadcast waves in the ionosphere. The LF/MF band radio receiver has ever consisted of analog circuit using super-heterodyne system. This receiver has been loaded on many sounding rockets and observed the propagation characteristics of radio waves in the ionosphere. And we could obtain the frequency components indicated by the propagation characteristics, such as the downward wave and the upward wave and the left and right handed waves by using the frequency analysis.

In this study we present how to obtain the specific frequencies of radio waves in the ionosphere using the digital radio receiver with the FPGA so that the receiver can be miniaturization and high-performance. Especially, we investigate that we obtain the specific frequencies, such as Doppler shift frequency, upward and downward wave frequency and so on, of many radio waves with the different frequency each other by using the digital radio receiver onboard the sounding rocket. Then it's investigated whether it's possible to obtain the horizontal structure of the electron density in the lower ionosphere by using a lot of radio data of different path observed along the rocket trajectory.

Electron Density Estimation by Using Simultaneous Observations of Lightning Optical Emissions and Whistlers from ISS GLIMS Mission

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The atmospherics from the lightning penetrating through the ionosphere and are observed as so-called lighting whistlers in the magnetosphere. Since ionosphere is the dispersive medium, group delays of whistler waves with different frequencies contain the information on the electron density along the propagation path.In this paper we estimate the maximum electron density of ionospheric F2 layer (NmF2) by using the time delay between the lightning optical emissions and associated whistlers, which were simultaneously measured by Global Lightning and SprIte MeasurementS (GLIMS) mission onboard ISS. We found that the calculated NmF2 by using group time delay are in good agreement with those estimated from classical dispersion analysis of lightning whistlers, IRI model and ionosonde for relatively small dispersion events. This method will be useful to cover the area where no ground-based measurements are available such as over the ocean and remote areas.

VHF Lightning Observations and DOA Estimation from ISS / JEM-GLIMS

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Global Lightning and sprIte MeasurementS (GLIMS) mission has been conducted on Exposed Facility of Japanese Experiment Module (JEM-EF) of the International Space Station (ISS) for more than 2 and half years. It is a space mission to observe global distributions of lightning and lightning-associated TLEs by combining observations with radio and optical sensors. This paper focuses on an EM payload of JEM-GLIMS mission, VITF, and its primary observation results.

VITF consists of two sets of antennas, band-pass filters, amplifiers, and 2-channel-AD-converter. Impulsive EM radiations received by the antennas are digitized by the AD converter synchronizing with another channel through the filters and the amplifiers. A patch type antenna is developed within the size of 200*200 mm. It is mounted on the antenna base made of aluminum alloy and Teflon block with the total height of 100 mm to gain its bandwidth and to reduce the interference from other structural objects. The same two units of antennas are installed with the separation of 1.6 m. Their bandwidths with the higher return loss than -3 dB are from 70 to 100 MHz. The signals received by the antenna are transmitted along cables with the same lengths to the electronics. The AD converter records 130 waveforms as maximum of one dataset with the duration of 2.5 μs with 200 MS/s. The developments of VITF are based on the heritage of VHF sensor on Maido-1 satellite. It is designed to estimate the direction-of-arrival (DOA) with about 10 km resolution that is equivalent to the scale of a thundercloud. It means that VITF is able to monitor thunderclouds with lightning activities globally. Comprehensive observations with the optical payloads of JEM-GLIMS mission for lightning activities and TLEs are expected to give us many scientific impacts to the field.

JEM-GIMS mission payload was successfully launched at the end of July 2012, and transported and installed to the ISS. After the initial checkout and maintenance, its nominal operation has been continuing from December 2012. Through the operation period, VITF corrects numerous VHF EM data synchronized with optical signals. 2,904 events with active VHF radiations out of 4,173 optical observations, about 70%, are observed for the 20 months in 2013 and 2014. The DOA estimations of the received VHF pulses are attempted using the broadband digital interferometry. Some results agree with the optical observations, even though DOA estimation has difficulties caused by its very short baseline of the antennas and multiple pulses in short time, namely burst-type EM waveforms. It is the worlds' first space-borne lightning location by EM DOA estimation. The DOA estimation via ionospheric dispersion is also applied the received VHF EM pulses. The simulated dispersion curves for various DOA with lay-tracing method and for received waveform enables to DOA estimation.

Beacon Experiment of Low-latitude Ionosphere from Southeast Asia

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We have been successfully conducted observations of total-electron content (TEC) of the ionosphere by the satellite-ground beacon experiment. An unique dual-band (150/400MHz) digital receiver GRBR (GNU Radio Beacon Receiver) were developed based on the recent digital signal processing technologies. The GRBR receivers were deployed first in Japan, and then in southeast Asia. Data from the GRBR network has been used for the investigations of variety of ionospheric phenomena. Especially in low-latitude region, longitudinal “large-scale wave structures (LSWS)” were studied in detail as a source of equatorial Spread-F (ESF) events. Also we were successful to measure the equatorial ionospheric anomaly (EIA) near 100E longitude in large latitudinal extent of at most +/-20 degrees around the geomagnetic equator. The technique is utilized for sounding rocket-ground experiment as well. Now there are several plans to launch several beacon satellites in the low-latitude region in 2015/2016, and a new project to develop new series of digital receivers has started this year. We review the ionospheric studies with the GRBR network, and discuss future direction of the related studies.

GNSS scintillations and ambient ionization near the northern EIA crest under superstorm event of March, 2015

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Abstract - Observations of GNSS scintillations and TEC from RPM College centre (22.655^{o}N, 88.348^{o}E), situated near the northern EIA crest, in the main phase of recent superstorm event of March 17-19, 2015 reveal opposite features contrary to quiet days, in the post sunset variability of TEC at two nearby longitudes 88^{o}E and 90^{o}E and occurrence of scintillation. On the 2nd day TEC at both the sectors exhibits extremely low diurnal values in conjunction with the whole day counter-electrojet event. PCA analysis of recovery phase TEC and EEJ reflect a good correspondence suggesting dominant contribution of disturbance dynamo field in ionospheric variability.

Estimation of Electron Density Using the Propagation Characteristics of Radio Waves by S-520-29 Sounding Rocket

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S-520-29 sounding rocket experiment was carried out at Uchinoura Space Center (USC) at 19:10 JST on 17 August, 2014. The purpose of this sounding rocket experiments is observation of sporadic E layer that appears in the lower ionosphere at near 100km. This rocket is equipped with LF/MF band radio receiver in order to observe of propagation characteristics of LF/MF band radio waves in rocket flight. LF/MF band radio receiver receives three radio waves of 873kHz (JOGB), 666kHz (JOBK), 60kHz (JJY) from the ground. In the sounding rocket experiment, LF/MF band radio receiver was working properly. We have completed the observation of radio wave intensity. We analyze the observation results using a Doppler shift calculations by frequency analysis. From the analysis, we obtained the propagation characteristics of LF/MF band radio waves and estimated the electron density of the ionosphere. As a result, 873kHz, 666kHz radio waves are reflected by the ionosphere. 60kHz wave was able to propagate in ionosphere because wavelength of 60kHz was longer than the thickness of the sporadic E layer.

In this study, we explain the result of LF/MF band radio waves observations and the electron density of the ionosphere using frequency analysis by S-520-29 sounding rocket.

A simple kinetic-fluid model for ion-scale waves in collisionless plasmas

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In this presentation, we discuss a simple kinetic-fluid model for obliquely propagating ion scale waves, which approximately includes the effects of ion kinetics and electron inertia. In the present study, the specific heat ratio of the Vlasov-MHD model[1] is applied to a two-fluid model with isotropic pressure[2]. The linear dispersion relation of the system is

$$[(M\omega^2 - k^2)T - C_S^2 k^2 k_y^2](M\omega^2 - k^2\cos^2\theta_{bk}) = \omega^2 k^4 \cos^2\theta_{bk} T. \quad (1)$$

where $T = \omega^2 - C_S^2 k^2$, $C_S^2 = \beta_f = \gamma_i T_i + T_e$, $M = 1 + m_e k^2$, and $k^2 = k_x^2 + k_y^2$. γ_i is the specific heat ratio defined by the past study[1].

Figure 1 shows (a)$\omega_r = Re[\omega]$ and (b)$-\omega_i$ of the shear mode (kinetic Alfvén waves ([4])) in the Vlasov-MHD model (1) and the full-Vlasov theory ([3]) in the case of $m_e = 1/1836$, $\theta_{bk} = 89°$ and $\beta_e = \beta_i = 2.0$. The agreement of the phase velocity (ω_r/k) and the growth rate among the models is observed when $k <\sim 5$. On the other hand, in contrast to the Landau fluid model ([4]), $-\omega_i$ of the Vlasov-MHD model decreases with increasing k at $k >\sim 5$. This may be due to the lack of the finite ion Larmor radius effects and correct evaluation of the transit time damping.

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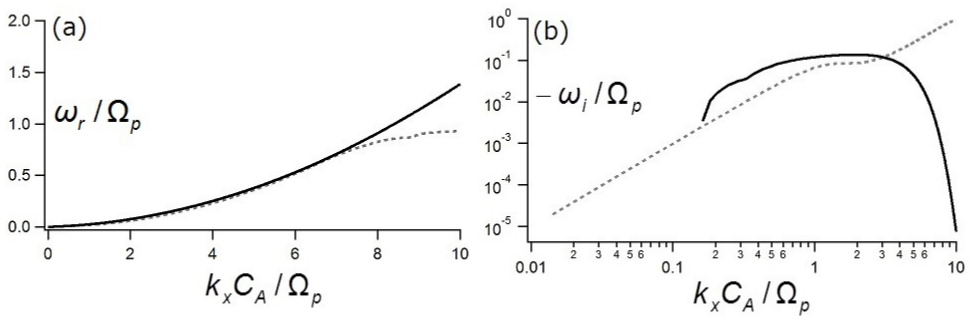

Figure 1. (a)$\omega_r = Re[\omega]$ and (b)$-\omega_i$ in the Vlasov-MHD model (1) (solid lines) and the full-Vlasov theory ([3]) (dashed lines).

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Collective Thomson scattering diagnostics in non-equilibrium plasma: Application to high power laser experiment

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The collective Thomson scattering is widely used to measure local quantities of a plasma in laboratory experiment. It is the application of the elastic scattering of low frequency electromagnetic waves by free electrons in a plasma [1]. In the measurement one observes scattered waves which are radiated through the interaction between an incident probe laser light and collective motions of electrons in a plasma. The characteristics of the scattered waves enable us to infer local electron density, plasma temperature, and valence of ions. Details of the scattering theory is complex. In particular the theory of the collective Thomson scattering in a non-equilibrium plasma has not been established well. Here, a high power laser experiment of a collisionless shock performed at the Institute of Laser Engineering, Osaka university, is taken as an example (Figure 1). The wave equation of the scattered waves interacting with a plasma containing arbitrary density fluctuations is numerically solved to discuss how the non-equilibrium plasma in a shock transition region scatters an incident probe laser light. In the past collective Thomson scattering measurement in a laboratory plasma the so-called ion feature is mainly paid attention, since the spectral intensity of scattered waves is relatively high. Here, we suggest that the electron feature, whose spectral intensity is usually very weak, can be observed in a highly non-equilibrium plasma as in the shock transition region.

Figure 1. Collisionless shock experiment at ILE.

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Dependencies of the Generation Process of Whistler-Mode Emissions on Temperature Anisotropy of Energetic Electrons in the Earth's Inner Magnetosphere

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Whistler-mode chorus emissions are electromagnetic plasma waves commonly observed in planetary magnetospheres. In the Earth's inner magnetosphere, chorus emissions are observed mostly on the dawn side and are enhanced during geomagnetically disturbed periods. Chorus emissions appear in the typical frequency range from 0.2 to 0.8 f_{ce0} with a gap at the half f_{ce0}, where f_{ce0} represents the electron gyrofrequency at the magnetic equator. Recent in situ observation in the magnetosphere revealed the presence of whistler-mode hiss-like emissions, whose wave amplitude is comparable to those of chorus emissions.

By a series of electron hybrid simulations, we study dependencies of the generation process of whistler-mode chorus and hiss-like emissions on temperature anisotropy of energetic electrons. The generation process of chorus has been reproduced in electron hybrid simulations and has been explained by the nonlinear wave growth theory [see review by Omura et al., 2012]. The generation mechanism of hiss-like emissions is also explained by the nonlinear wave growth theory and has been reproduced by simulations [Katoh and Omura, 2013]. In the present study, by an improved electron hybrid code with OhHelp library [Nakashima et al., 2009], we conduct a series of electron hybrid simulations for different temperature anisotropy (A_T) of the initial velocity distribution function of energetic electrons. We vary A_T in the range from 3 to 9 with changing the number density of energetic electrons (N_h) so as to study whether distinct rising-tone chorus emissions are reproduced or not in the assumed initial condition. Simulation results reveal that N_h required for the chorus generation decreases as A_T of energetic electrons increases and that reproduced spectra becomes hiss-like for large N_h cases. These simulation results clarify the validity of the nonlinear wave growth theory and suggest that the nonlinear wave-particle interactions play crucial roles in the generation process of whistler-mode chorus and hiss-like emissions in the magnetosphere.

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Study on Improvement of Direction Finding Method for VLF Waves

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Investigating characteristics of plasma waves observed by scientific satellites in the Earth's magnetosphere and plasmasphere is the effective key to understand not only generation mechanisms of the waves but also a plasma environment which influences its generation and propagation conditions. In particular, direction finding of plasma waves is most important for understanding these characteristics.

The wave distribution function (WDF) method was proposed for VLF waves in the Earth's magnetosphere/plasmasphere [1]. This method assumes that the observed signals are combinations of a continuum of superposed plane waves of different frequencies, propagating in different directions with no mutual phase coherence. In addition, this method also assumes that the observed signals are stationary and follow ergodic Gaussian random process with zero mean. Under these assumptions, the WDF method can estimate a WDF as directional distribution of wave energy density by using a spectral matrix which composes by cross spectra of observed signals. The WDF method is preferred when a wave source does not satisfy the plane-wave approximation or when it is widely extended. However, the WDF estimation is ill-posed problem, that is, the solution is not determined uniquely. Models as additional information for WDF must be needed to determine the solution uniquely. Many models have been proposed until now such as the Gaussian distribution model, and Markov random field model [2]. The estimation using these models works well if the sample number of observed signals is large enough to calculate spectral matrices exactly. Actually the number of sample observed by satellites is very few. We therefore must take into account that the spectral matrix which can be used for WDF estimation contains uncertainty.

We studied two issues for finding solution of above-mentioned problems. First, to treat the uncertainty, we used the Bayesian inference, and we introduced probability density distribution which determines relationship between observed and theoretical spectral matrices. This introduction makes the WDF estimation enable to take into account the effect of sample number. Second, we studied Markov chain Monte Carlo (MCMC) methods as a Bayesian inference method for WDF estimation. Variational Bayesian method is also well known as a Bayesian inference method for complicated probability model. In this method, we need to get a proper class of approximate probability distribution. However, we cannot get it due to the complexity of probability distribution we set. We therefore must select MCMC methods. MCMC methods have many types such as Metropolis-Hastings, Gibbs sampler, Hamiltonian Monte Carlo (HMC), and so on [3]. We investigated which type is better in terms of reliability and efficiency.

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Effect of Electron Core-Halo Drift Speed on the Strahl Formation in the Solar Wind: Particle-in-cell Simulations

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The halo is present at all pitch angles, whereas the strahl appears as a magnetic-field-aligned beam streaming away from the Sun. Recently, it was found that the strahl could be generated through nonlinear pitch angle scattering resulting from the interactions between the whistler waves excited by anisotropic core and the drifting halo electrons. The new scenario of local formation of the strahl was demonstrated by the particle-in-cell simulation. One of key parameters used in the simulation model is a relatively large core-halo drift speed. Such a drift is typically observed in the collisionless solar wind plasmas at 1 AU and its speed extends up to a few tens of the local Alfvén speed. In the present work, a parametric study is conducted to investigate how the core-halo drift speed affects the formation of the strahl. It is found that the threshold drift speed is necessary for effectively generating the stahl through pitch angle scattering of drifting halo when the whistler instability occurs in interplanetary space.

Low Frequency Characteristics of a Wire Antenna aboard a Scientific Spacecraft

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Observation of plasma waves in space is an important task for scientific satellites. In order to accurately determine the magnitude of the electric field of plasma waves observed by a scientific satellite, the calibration of the sensor must be accurate. For the observation of the electric field, a wire antenna which is a dipole antenna using a wire is often used. The effective length is one of the needed characteristics, however, it is difficult to acquire it in a ground test.

In order to study the estimation of the effective length, we have performed a rheometry experiment. In this experiment, a signal applied to two metal plate in water generates a quasi-static field between them (Figure 1.). The field is considered as the electric field of an electromagnetic wave and receiving it by an antenna, we can measure its output voltage. The magnitude of the electric field is known, so that we can calculate the effective length of the antenna from its output voltage. The frequency range of the experiment we have performed is from 10 Hz to 100 kHz.

And we have made a theoretical calculation method which is called DPS (Distributed Parallel Sources) method. In this calculation method, the electric field is approximated to a parallel circuit of potential sources. According of this method, we can make an equivalent circuit of the experiment, and calculate the value of the effective length as a function of the frequency. We have applied to this method to the experiment we have performed, and the calculation result is consistent to the experiment result.

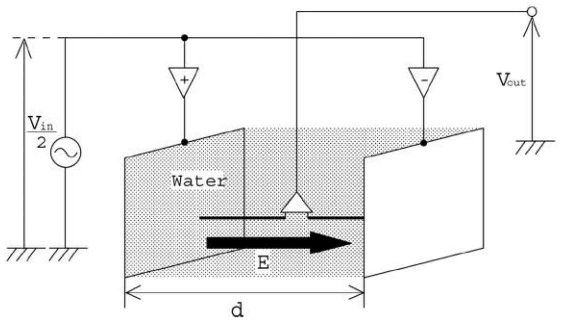

Figure 1. Overview of rheometry experiment

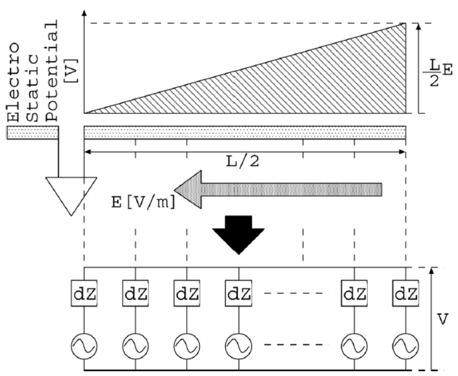

Figure 2. Basic concept of the equivalent circuit

In the present research we have investigate frequency dependence of the effective length of simple wire antennas, and found that the insulator which covers the side of wire cause frequency dependence at low frequencies. In this time we made a structure model of the actual satellite “ERG”, and investigate the effect of the deployment structure such as solar battery panels to the wire antenna. We will show the detail at the meeting.

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Effect of Lunar Surface Reflection on Polarizations of Auroral Kilometric Radiation Observed by KAGUYA

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The lunar orbiter KAGUYA frequently observed an electromagnetic wave from the Earth that is called AKR (auroral kilometric radiation). One of the interesting features of AKR observation from KAGUYA is that the observed AKR consists of not only waves reached directly from the Earth's auroral region but also waves reflected on the lunar surface [1, 2]. Reflection characteristics are determined by electrical parameters of the lunar surface. These parameters are, however, still unknown especially for low frequencies (LF band) although they may bring us a new knowledge about materials of the lunar surface.

The reflection influences polarizations of the observed AKR. Since KAGUYA is a three-axis stabilized (non-spinning) satellite and obtains only electric field on an antenna plane, measured polarizations depend on arrival direction of the AKR. When k-vector of the arrival AKR is perpendicular to the antenna plane, the measured polarization is equivalent to the true AKR polarization. On the other hand, when the k-vector is parallel to the antenna plane, the measured polarization is always linear regardless of the wave polarization. KAGUYA always keeps its antenna plane parallel to the lunar surface along the polar orbit of the Moon at an altitude of about 100 km. Thus, polarization should show a sinusoidal variation along the satellite movement if the reflection did not occur. In the statistical analysis of the observed polarization, however, the variation does not show pure sinusoidal curves due to the effect of the reflection.

In the present study, we examined whether the effect of the lunar surface reflection on the AKR polarization can be explained by a theoretical reflection model that is based on Fresnel equations. From the comparison between observed polarizations and those calculated for various parameter sets of original AKR polarization and the lunar surface, we obtained following results; (1) the original AKR polarization is perfectly circular, and (2) dependence of observed polarizations on incident angle is reconstructed under the condition that the permittivity of the lunar surface takes values from 4 to 8. The former result is consistent with observations of AKR from Cassini. As for the permittivity, it should vary depending on regions while we assume that it is constant all over the regions of the same incident angle. In that sense, the permittivity is an average value for each incident angle. In the future study, we will examine its regional dependences through detailed data analysis and compare them with permittivity map for high frequencies (HF band) that are derived from measurements by the lunar radar sounder instrument (LRS) on KAGUYA.

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Development of Automatic Detection of Omega Signals Captured by PFX Onboard Akebono

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The Akebono satellite was launched in 1989 to observe the Earth's magnetosphere and plasmasphere. Wave normal and Poynting flux Analyzer (PFX) is a waveform receiver measuring two components of electric field and three components of magnetic field with band-width of 50 Hz in a frequency range from 100 Hz to 12.75 kHz [1]. Omega was a navigation system transmitted from 8 different ground stations with transmission pattern every 10 s. Each station transmitted a different pattern of frequency but has common frequency at 10.2 kHz. The Omega system was terminated in 1997 giving way to the GPS system. The PFX onboard Akebono has received signals at 10.2 kHz from these stations from 1989 to 1997, and huge amounts of PFX data is valuable to study propagation characteristics of VLF waves in the ionosphere and plasmasphere around the Earth. In the present paper, we introduce detection method of Omega signals from the PFX data in a systematic way and show statistical features of Omega signals observed in the plasmasphere.

We first detect the raise time of each signal by comparing average intensity of specific time frame with threshold level expecting sudden increase of intensity. Second, we determine the transmission station by comparing the raise time and the transmission patterns of 8 Omega stations. Then we calculate the delay time of the signal subtracting the transmission time of the station. Next we calculate the intensity of the signal both for electric and magnetic components. The software we develop can analyze and show result of intensity and delay time map in geomagnetic or geographic map for both magnetic and electric field. Analyses of local time dependence is also available. In this study, we developed advanced method for automatic detection to process huge amounts of several years PFX's data. This method enables us to distinguish noises and also handle the error detection to produce accurate result and finding.

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Feasible Spectral Indices Measurement by Broad-band VLBI in VGOS Era

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To establish next generation geodetic VLBI, called VGOS (VLBI Global Observing System) which is based on the so-called broadband delay which uses four or more frequency bands in the range from 2.5 GHz to 14 GHz(1), we have been developing a broad-band system for Kashima 34 meter radio telescope which is the third largest radio telescope with cassegrain optics in Japan.

Currently we have installed two type of broadband feed (IGUANA-H and NINJA). Firstly for 6.5 GHz to 15 GHz since December 2013 and secondary 3.2 GHz to 14.4 GHz since July 2015. VGOS specification is 2.5GHz, but we designed the NINJA feed from 3.2 GHz to prevent highly RFI circumastances in Japan. Our broad-band system with ambient receiver system having the system temperature is about 150 Kelvin. The signal after the LNA transfers via optical fiber, then high-speed direct sampler called K6/GALAS converted analog to digital without frequency conversion.

By the way, full VGOS radio telescope is built by The Geospatial Information Authority of Japan in Ishioka, Ibaraki, Japan. The feasible broad-band VLBI sessions with Kashima 34 m and new VGOS-type Ishioka 13 m were carried out on January and July 2015. We carried out intensive sessions for 6 to 14GHz (6-bands, 2048Msps, 1bit). Fringes from every six frequencies could be simultaneously obtained after software correlation with GICO3 (2). Then a coherent phase connection over six frequencies were performed. An error of delay resolution function by the super bandwidth synthesis is estimated only 0.1 ps in 1 sec integration. Since we obtain 6 GHz bandwidth correlation result, we try to measure the spectral indices on broad-band correlation by comparing radio sources in these sessions. We will report more detail information in the meeting.

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Development of Wide-Band Bandwidth Synthesis Software for Geodetic VLBI

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Wide-band bandwidth synthesis (WBWS) is a technique to combine multi-band VLBI data of which bandwidth exceeds 10 GHz or more (band width is about 10 times wider than that of conventional bandwidth synthesis technique) not only to improve a delay resolution but also to increase a sensitivity of fringe detection. We have been developing WBWS software and have successfully applied it to actual wide-band VLBI data.

Three corrections considered in the development of WBWS software are as follows: 1) inner-band phase correction, 2) inter-band delay correction, and 3) ionospheric delay correction. As for corrections 1) and 2), a realistic method has been developed which corrects the phase and delay based on those obtained by a reference scan (which is usually defined as a scan observing a strong radio star). As for an ionospheric correction, it is not implemented yet in the software, but the total electron content (TEC) will be estimated by using the phase characteristics against the frequency. WBWS is applied to a wide-band VLBI observation data obtained by an experiment conducted on Kashima-Ishioka baseline in Jan. 16, 2015 and got a successful result (Figure 1).

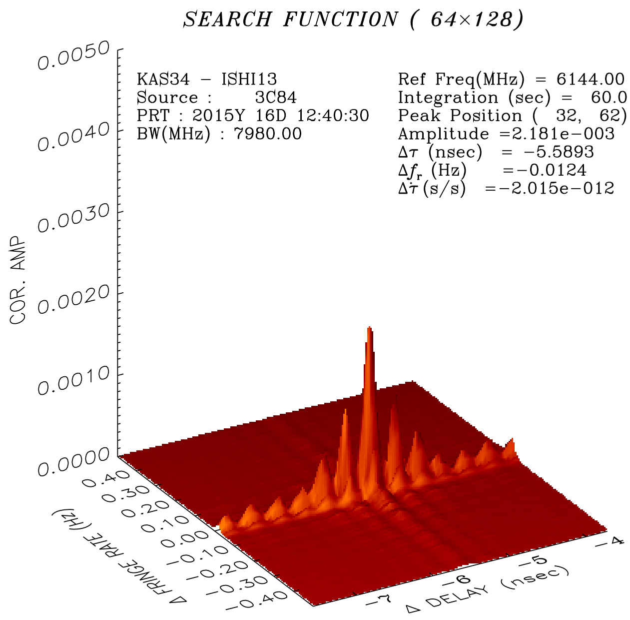

Figure 1: An example of so-called search function after WBWS for an observation on Jan.16, 2015 on Kashima-Ishioka baseline.

Development of Wideband Feed

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The Author developed wideband feeds for Kashima 34m antenna and small movable VLBI stations "MARBLE". These feeds are used for our study on Time and Frequency transfer with VLBI, which compares atomic clocks separated in long distance. However our wideband antenna can be used for other applications such as radio astronomy, geodesy or other observation needs wider bandwidth never done before.

This project of Kashima VLBI group was named Gala-V and covers 2.2-14.4GHz or more over. Frequency coverage of our Gala-V system, shown in Table 1, was defined to avoid RFI and minimize the data set of our VLBI observation. We hope our new technologies will be used in SKA(Square Kilometer Array), VGOS(VLBI Global Observing System) or other next generation projects. SKA and VGOS uses smaller wideband feed than us now, because they cannot develop wideband feeds for conventional cassegrain antennas which needs feeds with narrower beam width and larger aperture size. Thus they have limited design strategy, however we can arrange the beam size of feed for cassegrain antenna or center focus of the parabola or other optics in our design capabilities.

Now two types of wideband feeds were installed in 34m antenna. The first is a prototype of IGUANA feed designed for 2.2-18 or up to 22GHz. IGUANA feed was named after Gala-V, Gala-V was named from unique evolutions in Galapagos, off course, V is for VLBI. This prototype is designed for higher frequency band of IGUANA, thus it is called IGUANA-H and now used in 6.5-15.0GHz with 30-50% aperture efficiency of 34m antenna, which is shown in right of Figure 2. First prototype was set in 34m antenna at the end of 2013, and the second replaced it in 2014 and is used still now. The Author previously designed multimode horns for ASTRO-G/VSOP-2 satellite, 6.7GHz feeds for 20m antennas of VERA project in National Astronomical Observatory and 25m antenna in Shanghai, and now, they were arranged for Gala-V.

The other new Wideband feed is designed for 3.2-14.4GHz, named NINJA Feed, is shown in left of Figure 2. Aperture efficiency of 34m antenna with NINJA is shown in Figure 3. however, it will be improved after adjusting the feed positions. They replaced in previous two C-band feeds in 34m, which both are corrugated horns for 5GHz and 10GHz. These new wideband feeds brought us more wider simultaneous bandwidth which no other large radio telescopes have. The Author supposes the IGUANA feed with 2.2-18 or 22GHz coverage will be manufactured in 2015 or early 2016.

Table 1. Frequencies of Gala-V

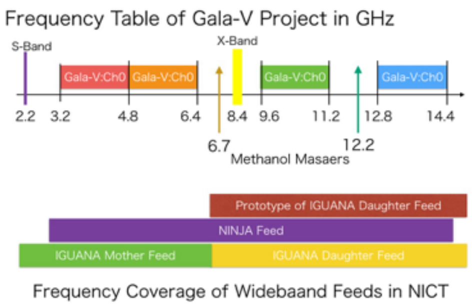

Figure 1. Kashima 34m antenna(photo by T.Kondo).

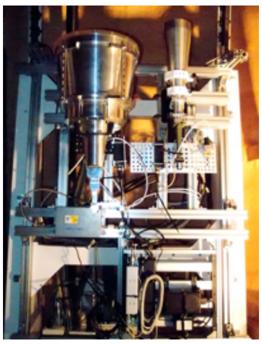

Figure 2. Wideband feeds in Kashima 34m antenna.

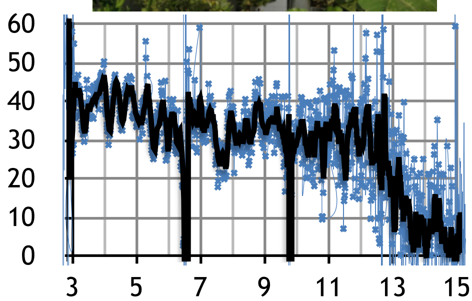

Figure 3. Aperture efficiency of 34m antenna with NINJA feed(Aug.6,2015, measured by K.Takefuji).

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New X-band Receiver System of Usuda 64m Antenna

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We have used the S/X-band common feed port for the spacecraft operation, for the radio astronomy using Usuda 64m antenna (Figure 1). This X-band receiving system connected to this port has higher system noise temperature because it has some microwave circuits, such as diplexer, filters, and waveguide switch in room temperature, which are all required for the spacecraft, and has narrower (~ 300 MHz) band pass for radio astronomy. Because of the improvement of backend of the radio-astronomy system, more than 500 MHz bandwidth is required for getting better sensitivity to observe continuum sources.

We have paid attention to the unused X-band receiving-only feed (#6 port) of Usuda 64m, and developed new receiver (Figure 2) to attach it. The new receiver is consist of thermal insulating waveguide, septum type low loss circular polarizer, coupler for calibration signal insertion, and 2-low noise amplifiers (LNA's) for both LHCP and RHCP detection.. All of those are operated in the dewar cooled less than 10 K. 2-LNA's are LNF-LNC7_10A made by Low Noise Factory, and has 36 dB gain, and 4 K receiver noise temperature in 8.0-8.5 GHz at the physical temperature of 9 K environment[1].

We installed this receiver at the port #6 of Usuda 64m and measure the system temperature and antenna efficiency though port #6. We have got the typical system noise temperature at zenith 25-30 K, and 45 % antenna efficiency, which improved the noise level of 2-3 times better. Furthermore, this new receiver allows us to extend the observing bandwidth for the continuum sources. Total improvement of the sensitivity is factor 4-5, which allow us to observe new category of sources.

Using this receiver we made VLBI observation with Tsukuba 32m (GSI), Yamaguchi 32m (Yamaguchi Univ. and NAOJ), and Ibaragi 32m (Ibaragi Univ. and NAOJ) on May 5^{th,} 2015, and successfully confirmed we can use this new system for X-band VLBI observation. This receiver allows us to do high sensitivity VLBI observation and signal detection in X-band.

Figure 1 Picture of Usuda 64m Antenna

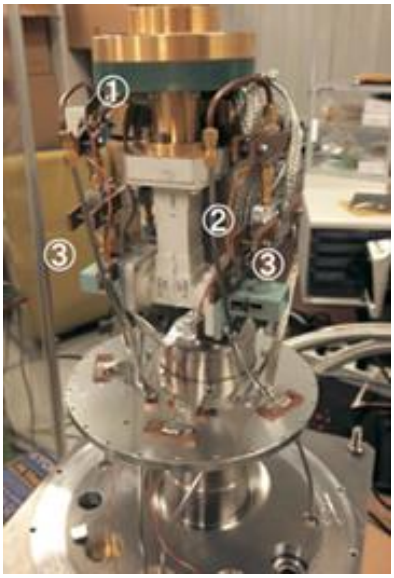

Figure 2 Inside of new X band receiver. (1) Thermal insulated wave guide, (2) Circular Polarizer, (3) Low Noise Amplifier, LNF-LNC7_10A

References

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Source/Frequency Phase Referencing for 22 GHz H_2O Masers and 43 and 86 GHz SiO Masers of the Red Supergiant, S Per

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We report on astrometric study results of quadruple maser lines of the red supergiant S Per with a novel VLBI astrometric analysis method of source/frequency phase referencing (SFPR) using the joint VLBI array, KaVA, consisting of a Japanese VLBI array of the VERA and a Korean VLBI array of the KVN. We observed microwave to millimeter wave maser lines of H_2O at 22 GHz, $v = 1$ and 2, $J = 1 \rightarrow 0$ SiO at 43 GHz, and $v = 1$, $J = 2 \rightarrow 1$ SiO at 86 GHz of the circumstellar envelop (CSE) of S Per and a nearby calibrator, ICRF J0244+6228, as a positional calibrator with the separation angle of 4°. The fringe phases of the 43 and 86 GHz SiO masers ($v = 1$ and 2, $J = 1 \rightarrow 0$, and $v = 1$, $J = 2 \rightarrow 1$) were calibrated with those of the H_2O maser with the radial velocity of -50 km s^{-1} using multi-frequency phase referencing (MFPR) in order to improve coherence at the higher frequencies. In addition, to compare the relative positions between those four maser lines without astrophysical assumptions, MFPR for the calibrator was also conducted to calibrate frequency band dependent phase errors such as phase differences of receiver instruments and ionospheric phase delays. The H_2O maser image of S Per and ICRF J0244+6228 images were made with the KaVA data with good quality while the SFPR data analysis has been made with the KVN data. Because of a trouble during the observation, only one baseline of the KVN was available for the SFPR data analysis.

The SFPR imaging of the $J = 1 \rightarrow 0$ SiO masers at 43 GHz was successful, and we could achieve astrometric analysis between the 22 GHz H_2O and the 43 GHz SiO masers by a simple superposition of the images. The 43 GHz SiO masers is located at around the center of the H_2O maser distribution along a northeast–southwest direction. At 86 GHz, the SFPR analysis was also successful, and we could confirm the maser emission in the cross power spectrum after SFPR while it can hardly seen before SFPR due to very rapid fringe phase fluctuations. On the other hand, a synthesis image at 86 GHz could not be made with good quality because the cross power spectrum amplitude and phase has a rapid time variation. This indicates that the 86 GHz SiO maser emission has more complicated structure which could not retrieve with the single KVN baseline.

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Hours Timescale Radio Transients Detected by the Nasu Radio Telescope Array

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We report on the discovery rate of transient radio sources with a timescale of hours. The Nasu radio telescope array surveyed an area of 0.5 million square degree and discovered a transient object, labeled WJN J1443+3439 [1], from an unknown origin. Its flux variability is thought to have lasted from minutes to days (convincingly, hours). On the basis of this single detection, the sky surface density, Σ, of live radio transients was estimated to be $\Sigma^{>3\ \mathrm{Jy}}_{1.42\ \mathrm{GHz}} = 2^{+9}_{-1.9} \times 10^{-6}$ deg^{-2} at a flux density above 3 Jy and a frequency of 1.42 GHz [2]. Defining the event rate, R, as the sky surface density divided by the flux variability timescale, τ, we estimated the event rate to be $R^{>3\ \mathrm{Jy}}_{1.42\ \mathrm{GHz}} = 1^{+7}_{-1} \times 10^{-3} (\tau/0.5\ \mathrm{day})^{-1}$ deg^{-2} year^{-1}.

The left panel of Figure 1 shows the consistency between our result and others. The discovered transient, WJN J1443+3439, locates within the shaded region in the right panel of Figure 1. From that point of view, the transient might originate from a flare star or an active galactic nucleus.

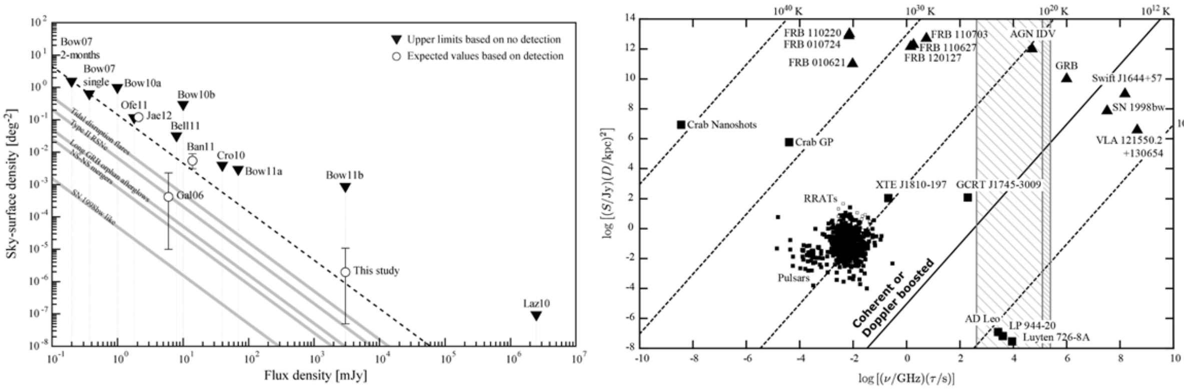

Figure 1. Left: Log-log plot of sky surface density $\Sigma^{>S}$ vs. flux density S for radio transients. Several survey results are plotted disregarding observation frequencies. Right: Parameter space of variable and transient radio sources. The vertical axis indicates luminosity, SD^2, for flux density S and distance D. The horizontal axis indicates the product of emission frequency ν and variability timescale τ.

Assuming a power-law relation between source count and flux density, the surface density of $\Sigma^{>3\ \mathrm{Jy}}_{1.42\ \mathrm{GHz}} = 2 \times 10^{-6}$ deg^{-2} yields $\Sigma^{>S}_{1.42\ \mathrm{GHz}} = 0.3 \times (S/\mathrm{mJy})^{-3/2}$ deg^{-2}. From a statistical perspective, to verify our survey result of $\Sigma^{>S}_{1.42\ \mathrm{GHz}}$ with 95% confidence, a survey area needs at least $10 \times (S/\mathrm{mJy})^{+3/2}$ deg^2 on the sky. If the WJN J1443+3439 shined on a timescale of minutes, it seems too difficult to detect such events for the existing radio facilities; therefore, the Square Kilometre Array (SKA) with instantaneously high sensitivity is needed. Our survey result will be completely verified by the SKA1-MID array under its system baseline design in 2013 (0.83 deg^2 field of view, 1.69 Jy system equivalent flux density, and 800 MHz bandwidth).

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Microwave Induced Oxidative Stress Mediated Toxicity on Male Fertility Pattern and possible protective measures

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ABSTRACT

The present evidence on mobile phone radiation exposure is based on scientific research and public policy initiative to give an overview of what is known of biological effects that occur at radiofrequency (RF)/ electromagnetic fields (EMFs) exposure. The reviews of last few decades on health endpoints reported to be associated with RF include childhood leukaemia, brain tumours, genotoxic effects, neurological effects and neurodegenerative diseases, immune system deregulation, allergic and inflammatory responses, infertility and some cardiovascular effects. Most of the reports conclude a reasonable suspicion of mobile phone risk based on clear evidence of bio-effects. Present study has been focused on bio-interaction mechanism between mobile phone exposure and possible health effects which may be occur due to reactive oxygen species (ROS) formation. Available data suggests that increased ROS play an important role by enhancing the effect of radio frequency radiations which may cause infertility as well as neurodegenerative diseases.

Several studies have reported significant ($P< 0.05$) causative effect of radio frequency electromagnetic field on different organs with different parameters like; DNA strand break, apoptosis, melatonin, creatine kinase, PKC etc. But in the present scenario, very less or almost none has found a solution against protection to these radiations. Here we are going to discuss the possibility of therapeutic or retrieval impact of herbal plants and antioxidant enzymes in response to RF-EMF radiations. There are several known herbal plants available with known compounds which can act as antioxidants, anti cancerous leads. Radioprotective potential of caffeic acid (green tea) and its extracts are rich source of polyphenolic compounds. The polyphenols present in green tea (*Camellia sinensis*) have numerous health benefits due to their anti-inflammatory and anti-oxidant activities which may also be useful agents against microwave exposure. Moreover, pulsed electromagnetic field (PEMF) therapy is a non-invasive, simple technique that can be used as a scavenger agent to combat oxidative stress. Pulsed electromagnetic field therapy provides significant protection by controlling ROS production. Also another compound, melatonin has strong antioxidative potential against microwave radiation induced oxidative stress mediated DNA damage in barin and testicular cells.

The above discussed studies are an important issue in the present scenario. Because most of the population (more than 95%) are using cell phones and also microwave appliances. The whole study will explore the possible mechanism of microwave radiation interaction and also protection against these radiations.

Key words: Cell phone, Apoptosis, ROS, Antioxidant

Temperature and frequency dependent on electrical properties of swine liver

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In recent years, electromagnetic waves (EM) are indispensable for our life because they were used in many situations, for example, telecommunications, home electrical appliance and medical applications (e.g. hyperthermia, body-centric wireless communications). With the spread of the mobile radio terminals, a lot of studies in the ultra-high frequency (UHF) band and above have been made [1]. In particular, it has been studied about the effect of EM waves in the UHF for biological tissue by using of mobile phones. Therefore, there are a lot of data about electrical properties of biological tissue in the UHF [2]. Those data can be used for making phantoms and numerical calculations. There are some frequency bands like the high frequency (HF), and the medium frequency (MF) that have lower frequency than the UHF band. Although, these frequency band (range from hundreds kilohertz to tens megahertz) are used to some medical devices such as an electro surgical knife and a hyperthermia, few studies have been reported [3]. As a result, there is not enough data about electrical properties of biological tissue in the MF and HF band, especially the data taking into consideration about changes of electrical properties caused by temperatures and coagulations. Therefore, it is necessary to study about electrical properties of biological tissue in the MF and HF band. I

In this study, we heated the fresh swine liver gently until coagulation and measured its electrical properties (relative permittivity and conductivity).We used the two terminal method using a LCR meter (6530B, Wayne Kerr Electronics, London) for measurement. We investigated temperature dependent on electrical properties of swine liver from 0.3 MHz to 30 MHz with these data. Figure shows the result of mesurement at 0.3MHz. Relative permittivity and conductivity greatly changed between 60 °C to 70 °C. It appears these great change of electrical properties between 60 °C and 70 °C are caused by the destruction of cell membrane.

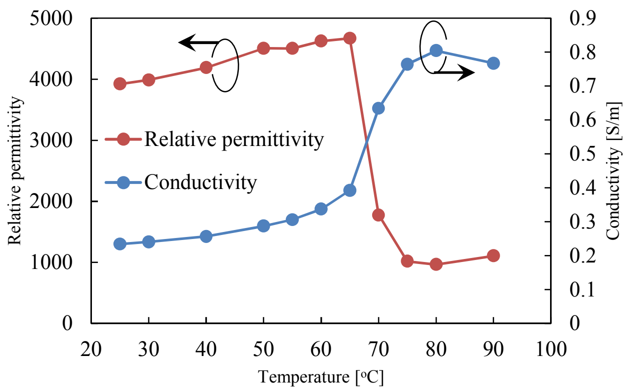

Figure Electrical properties at 0.3 MHz

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Development of Biological Tissue Coagulating and Cutting Device Combining Microwave and Radio Frequency Current

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1. Introduction

Various types of surgical devices using microwave energy in order to stop bleeding from the organs and blood vessels are investigated and reported [1]. For smooth progress of the surgery, surgical devices are required to have multi functions: tissue coagulation and tissue resection. Generally, microwave energy is used for tissue coagulation and unsuitable for tissue resection because of the mild heating effect. Here, devices using joule heating by discharging radio frequency (RF) current are employed for tissue resection. In this study, a hybrid surgical device for tissue coagulation and resection with the microwave energy which has a good coagulation ability and radio frequency current which has a good resection ability is proposed. In this abstract, the heating characteristic of the designed microwave heating antenna for tissue coagulation loaded with the RF electrode for cutting device is simulated.

2. The proposed device and the calculation model

Figure 1 shows the designed heating antenna. In Fig. 1, antenna elements are connected to an inner conductor and an outer conductor of the coaxial cable. Moreover, an active electrode which emits RF current is loaded with the proposed device. In analysis, a copper plate is assumed as the active electrode. Each element is covered with polytetrafluoroethylene (PTFE) in order to prevent adhesion of the coagulated tissue. However, the length of 2 mm from the tip of the other heating antenna connected to the outer conductor is not covered with PTFE in order to emit RF current. Figure 2 shows the calculation model simulating the situation when the tip of the proposed device is pressed to the surface of liver tissue. The operating frequency, input power to the device, and heating duration were set to 2.45 GHz, 30 W, and 10 s, respectively.

3. Conclusion

Figure 3 shows a temperature distribution on the surface of liver tissue attached the proposed device (*x*-*z* plane). In Fig. 3, the parts of blood vessel near the heating antenna elements are heated more than 60 ºC. Moreover, the reflection coefficient at the feeding point of the device is approximately -12 dB. As these results, it is confirmed that the designed antenna is useful as the heating antenna loaded with the RF electrode.

As further study, the proposed device will be produced and its heating characteristic will be evaluated experimentally.

4. Acknowledgement

This work was supported by Grant-in-Aid for Scientific Research (C) Grant Number 15K06010.

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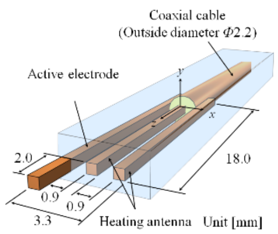

Fig.1 Heating antenna.

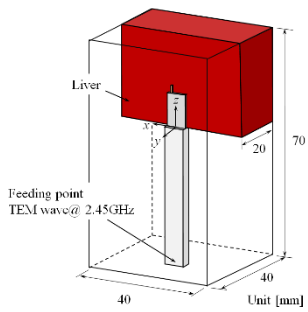

Fig.2 Calculation model.

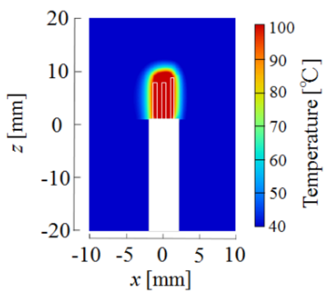

Fig.3 Temperature distribution.

Study on Cytotoxicity of 0.07-0.30 THz Wave Exposure at Cultured Cells

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We study on biological effects of exposure to THz radiation and explore the resonant vibration of cell membrane based on the Frohlich hypothesis. Terahertz (THz) wave has characteristics of both radio waves and visible light. This frequency will be expected early commercial use. However there are few experimental data about safety of human body in this frequency range. So we need more investigate regarding possible health effects.

We have carried out culture experiments to examine the cytotoxicity of 0.07-0.30 THz exposure in two cultured human cell lines, NB1RGB (fibroblast) and A172 (glioblastoma). The Uni-Traveling Carrier Photodiode (UTC-PD, NTT Electronics Incorporation) was used as a widely tunable THz/MMW source with several micro watt output power. The distance between UTC-PD head and the cultured plate was 100 mm. The frequency was tuned within the 0.07-0.30 THz range by 1.0 GHz step by changing the difference frequency between two pump CW fiber lasers. We have measured the cell viability assays using MTS assay which was colorimetric method to determine the number of viable cells in proliferation or cytotoxicity assays. This assay was based on metabolic activity to uptake and the reduction reaction of MTS reagent by mitochondrial dehydrogenase. The absorbance was recorded at 490 nm with Microplate reader. To research effect of the THz exposure at cell proliferation, the cells cultured 70 hours with radiated 0.07-0.30 THz wave. Then colorimetric reaction for MTS assay was three hours without irradiation, and absorbance was measured. Another experiment, after 72 hours cultured cells without irradiation, MTS assay was carried out three hours with irradiation for researching the cytotoxicity. Experiments were replicated three times.

The results show absorbance of irradiated cells was not decreased compared to sham cells. So we did not find cytotoxicity of exposure at 0.07-0.30 THz in MTS assay. This suggests 0.07-0.30 THz exposure will not cause human skin damage by ultra-weak power. However we need more detail research in this THz range.

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Conference Events

Opening Ceremony

9:00-9:15 (September 3, 2015)
Multi-Purpose Digital Hall, West Building 9

MC: Satoshi Yagitani (Chair, URSI-JRSM 2015 Technical Program Committee)

Opening Address:

Kazuya Kobayashi (URSI-JRSM 2015 General Chair; President, Japan National Committee of URSI; URSI Assistant Secretary-General (AP-RASC); Vice-Chair, URSI Commission B)

Makoto Ando (URSI Vice-President; Executive Vice President for Research, Tokyo Institute of Technology, Japan)

Poster Session

15:30-18:00 (September 3, 2015)
Media Hall / Collaboration Room
West Building 9

Instructions for Poster Presentation:

The board size for the poster presentation is 1700 mm (height) and 1150 mm (width). The poster size should be less than A0 size (1189 mm height and 841 mm width). Authors are required to use only the boards corresponding to their posters. Each poster board is marked with a poster ID-number, which can be found in the poster program.

Please keep in mind that the poster message should be clear and understandable without oral explanation. Please use an appropriate font size allowing posters to be readable by participants from 2 m away.

Posters can be put up from 12:15 on September 3, 2015. After the poster session is over, all the posters should be removed immediately.

Exhibition

15:00-18:00 (September 3, 2015)
Media Hall, West Building 9

List of Exhibitors:

- AET, INC.
- MITSUBISHI ELECTRIC CORPORATION

Technical Tour

10:30-16:30 (September 3, 2015)
10:30-16:30 (September 4, 2015)
Tokyo Tech Museum, Centennial Hall

Participants are free to explore Tokyo Tech Museum in Centennial Hall on their own any time during USRI-JRSM 2015. An exhibition room on the 2nd floor highlights the evolution of electronics and the development of photonics at Tokyo Tech (Tokyo Institute of Technology), including the invention of the high-stability quartz oscillator by Prof. Issac Koga. During URSI-JRSM 2015, Issac Koga Gold Medal, which is presented to an outstanding young scientist under the age of 35 by the Japan National Committee of URSI on the occasion of the “URSI General Assembly and Scientific Symposium” (URSI GASS), will also be displayed.

URSI-Japan Commission Business Meetings (open to all participants)

13:00-13:45 (September 3, 2015):

Commission B: Room W935, West Building 9
Commission E: Room W936, West Building 9

12:15-13:25 (September 4, 2015):

Commission A: Room W321, West Building 3
Commission C: Room W934, West Building 9
Commission D: Room W935, West Building 9
Commission F: Room W936, West Building 9
Commission G: Room W932, West Building 9
Commission H: Room W933, West Building 9
Commission J: Room W322, West Building 3

Banquet

18:30-20:30 (September 3, 2015)
Student Hall

MC: Jun-ichi Takada (Assistant Secretary, Japan National Committee of URSI)

Welcome Address:

Satoshi Yagitani (Chair, URSI-JRSM 2015 Technical Program Committee)
Alexander I. Nosich (Professor / Principal Scientist, National Academy of Sciences of Ukraine, Ukraine)

Toast:

Yasuhiro Koyama (Chair, URSI Commission A)

During the Banquet, three finalists for Student Paper Competition (SPC) will be announced.

Closing Ceremony

16:30-17:00 (September 4, 2015)
Multi-Purpose Digital Hall, West Building 9

MC: Jun-ichi Takada (Assistant Secretary, Japan National Committee of URSI)

SPC Award Ceremony:

Winners of SPC will be awarded the 1st, 2nd and 3rd prizes.

Closing Address:

Kazuya Kobayashi (URSI-JRSM 2015 General Chair; President, Japan National Committee of URSI; URSI Assistant Secretary-General (AP-RASC); Vice-Chair, URSI Commission B)

URSI-JRSM 2015 Steering Committee Meeting (members only)

12:15-13:15 (September 3, 2015)
Room W931, West Building 9

SPC Committee Meetings (members only)

SPC Committee Meeting 1:

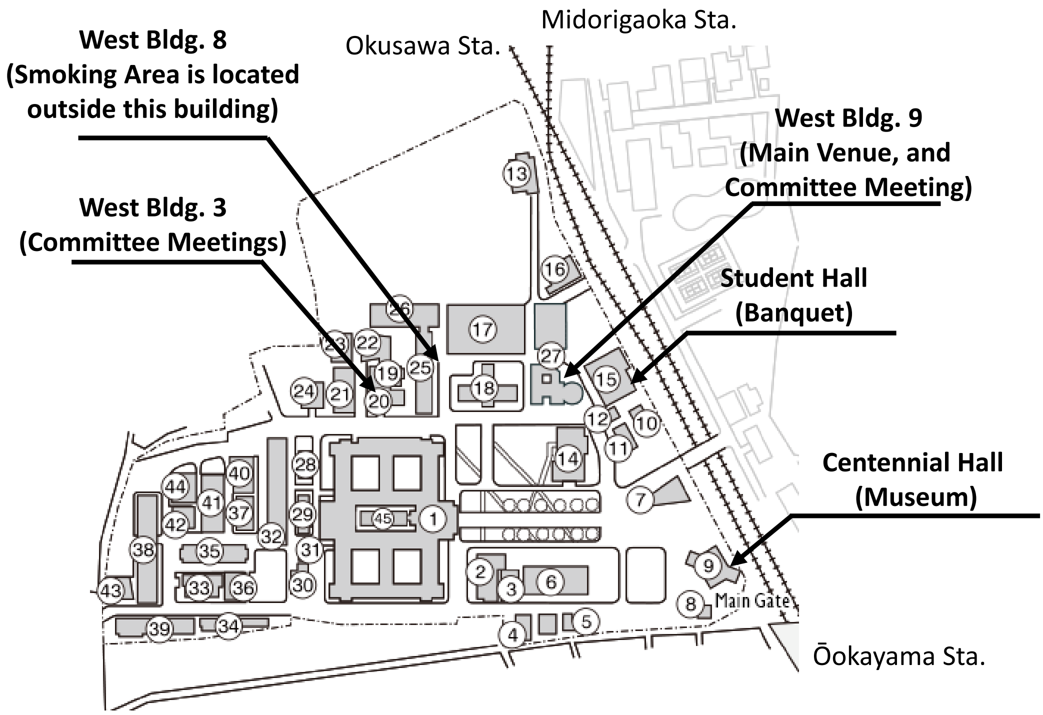
17:25-18:10 (September 3, 2015)
Room W931, West Building 9

SPC Committee Meeting 2:

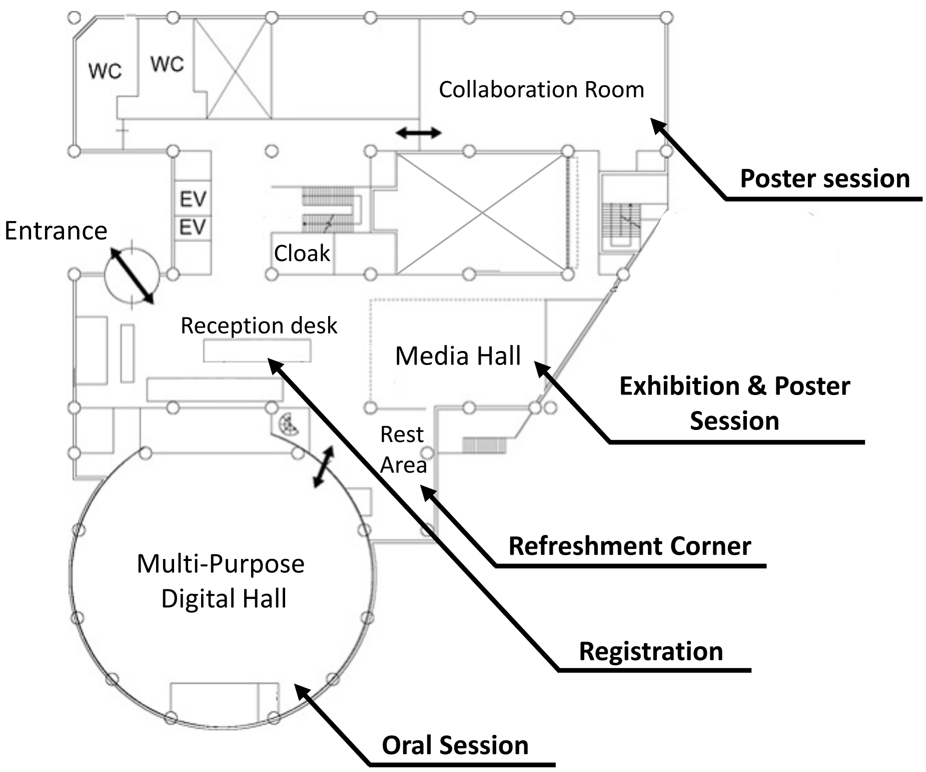
13:25-13:45 (September 4, 2015)
Room W931, West Building 9

Floor Guide

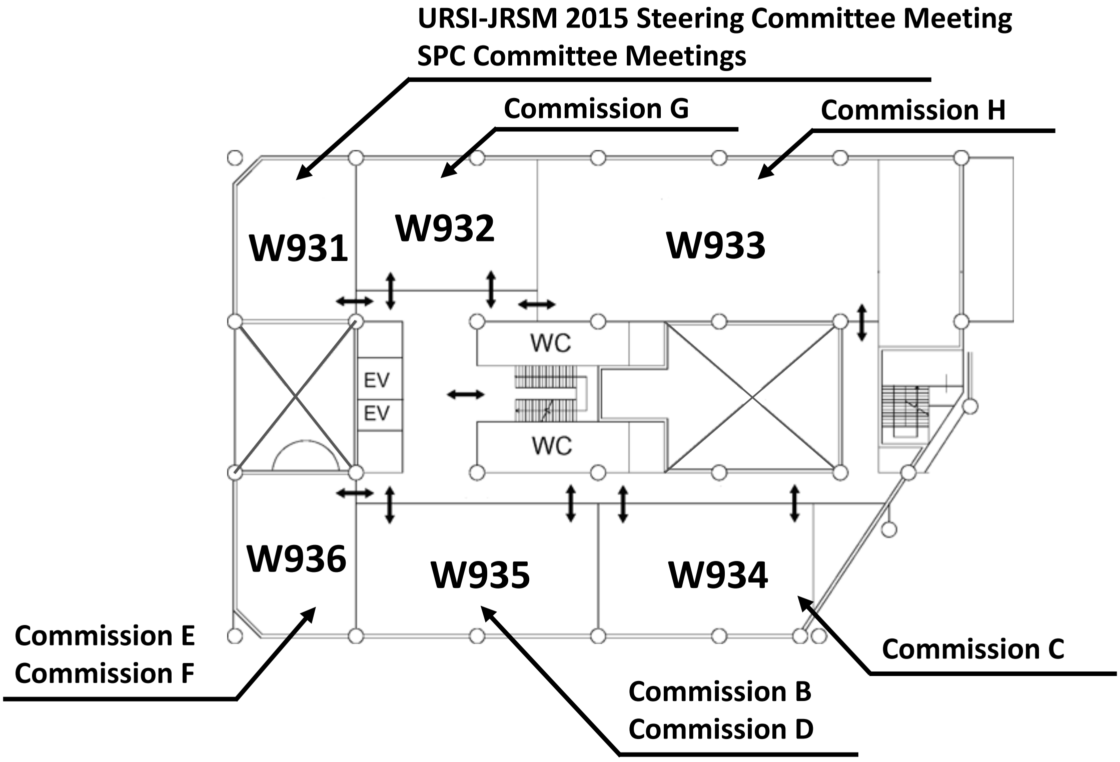
Campus map, Tokyo Institute of Technology



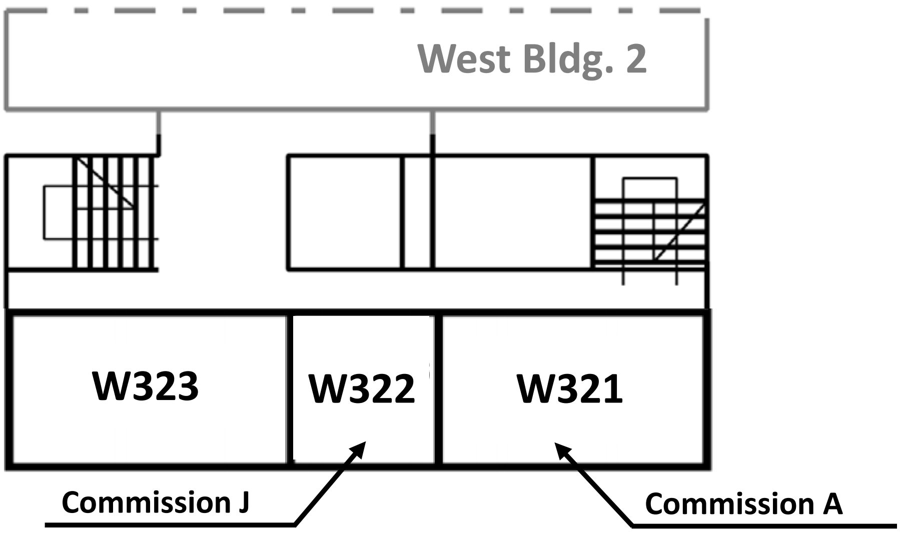
2nd Floor, West Building 9



3rd Floor, West Building 9



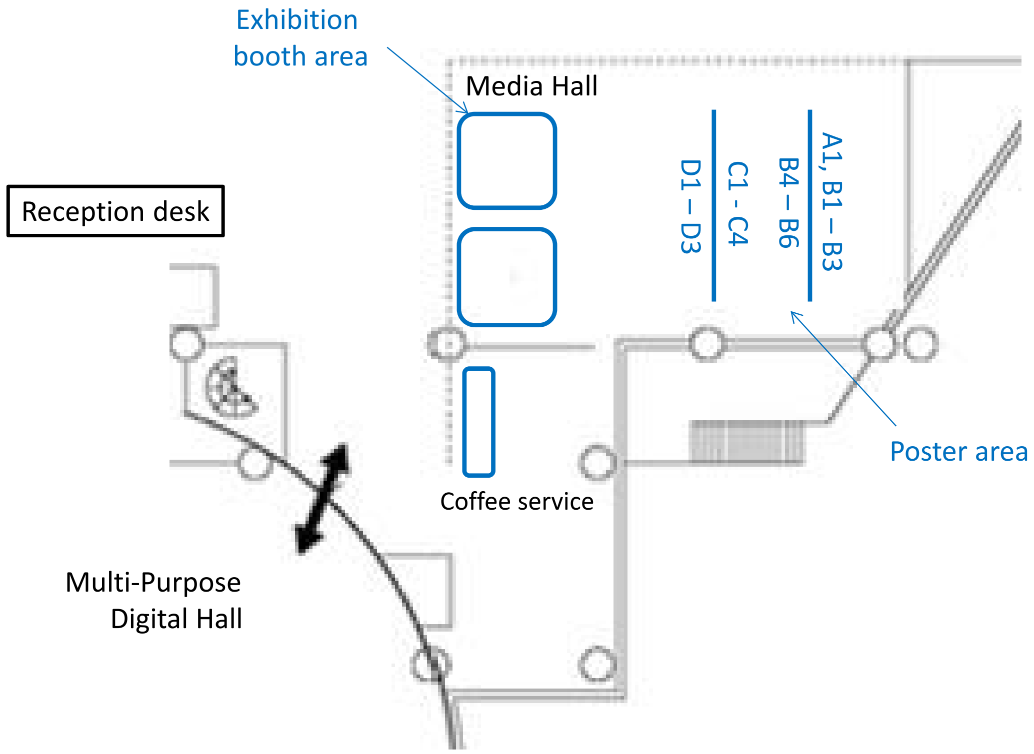
3rd Floor, West Building 3



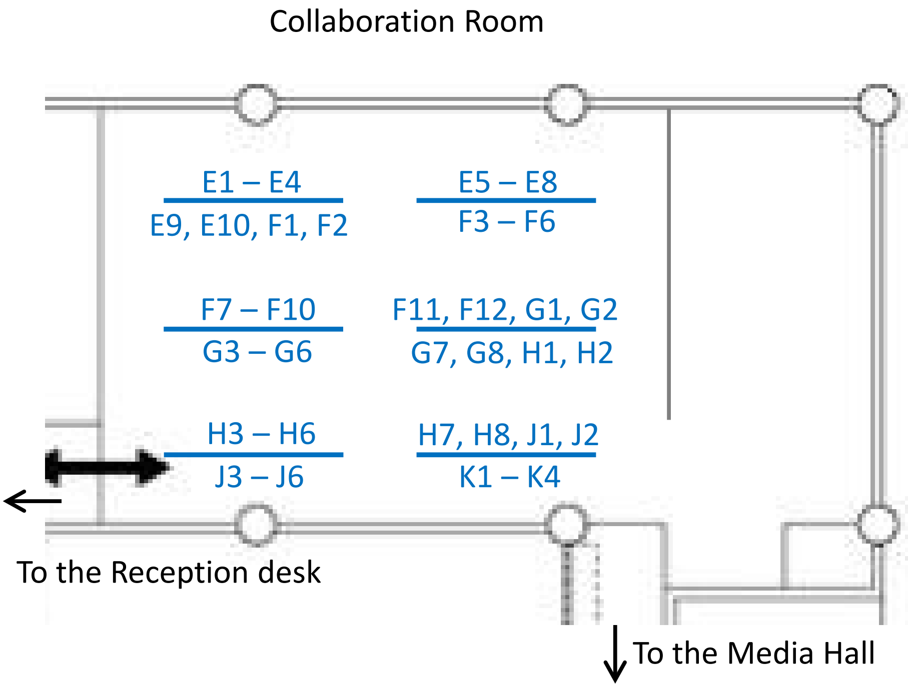
The front entrance of the building is located on the 3rd floor.
Please go down to the 2nd floor to find these meeting rooms.

Posters and Exhibition

Media Hall, West Building 9



Collaboration Room, West Building 9



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