2011 THz Workshop

民國百年 兆赫科技研討會

Proceedings

Time: December 12, 2011

Venue: Room 019, Physics Building

Conference Organizer

Department of Physics, National Tsing Hua University

Tsing Hua Optics & Optoelectronics Research

Sponsors

前瞻物質基礎與應用科學中心
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國立清華大學 1911-1956-2011 55 NTHU ANNIVERSARY

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前言

Welcome Message

Greetings, and welcome to the ROC Centennial Workshop on THz Science and Technology (THz Workshop 2011), held in Hsinchu, Taiwan on Dec. 12th, 2011.

Our intention, and that of the sponsoring organizations, is to provide a venue where attendees can explore the latest cutting-edge research and applications of THz science and technology.. The workshop was also held in celebration of the 100th anniversary both of the Republic of China and Tsing Hua University. This year, THz workshop 2011 covers a broad range of topics, e.g., high-power THz radiation sources, THz spectroscopy and sensing, THz metamaterials and .THz wireless communications. We are very pleased and indeed honored to have distinguished guests from Fukui University's renowned Research Center for Development of Far-Infrared Region as invited speakers. They will be joined by our local scholars, who will contribute many invited talks and poster presentations in the technical program.

THz workshop 2011 is most grateful to all of our sponsors, the Frontier Research Center and Applied Sciences of Matters, Office of Research and Development in NTHU and Physics Research Promotion Center, NSC, who graciously provide the much needed financial support to stage this event. Your participation is of course most essential in making THz workshop 2011 a great success and at the same time showcasing the strength, dynamics and the diversity of Taiwan's academic and industrial communities in THz research and technology development.

As Conference Chair, I cordially invite all of you to participate and enjoy the excitement and fun of THz workshop in Hsinchu.

Ci-Ling Pan
Conference Chair, THz Workshop 2011
Professor and Chair, Dept. of Physics
National Tsing Hua University
Hsinchu, Taiwan
Republic of China

民國百年兆赫科技研討會議程

Workshop Agenda

2011 THz Workshop

民國百年兆赫科技研討會

National Tsing Hua University, Hsinchu, Taiwan

December 12, 2011

Agenda	**Venue：Room 019, Physics Building, NTHU**
09:00 –09:10	**Opening remarks 大會開幕致詞** ***Chair :Prof. C. L. Pan***
Session I	**High-power THz radiation sources(I)** ***Chair: Prof. C. L. Pan***
09:10 – 09:40	*High power THz radiation sources developed in FIR FU- Gyrotrons FU and FU CW Series* Invited talk (Ia) Prof. Toshitaka Idehara (University of Fukui) 邀請講演 (Ia) 出原敏孝 教授(福井大學)
09:40 – 10:00	*Desktop mW-MW Coherent THz-wave Sources* Invited talk (Ib) Prof. Yen-Chieh Huang (Institute of Photonics Technologies, NTHU) 邀請講演 (Ib) 黃衍介 教授(清華大學光電工程研究所)
10:00 – 10:20	*Coherent THz Radiation from Ultrashort Electron Pulses* Invited talk (Ic) Dr. Wai-Keung Lau (National Synchrotron Radiation Research Center) 邀請講演 (Ic) 劉偉強 博士(國家同步幅射研究中心)
10:20 – 10:40	Coffee break and poster session P1 茶敘及壁報欣賞 P1
Session II	**High-power THz radiation sources(II)** ***Chair: Prof. T. H. Chang***
10:40 – 11:10	*Competition between Harmonic Cyclotron Maser Interactions in the Terahertz Regime* Invited talk (Id) 科學50 Prof. Kwo-Ray Chu (Department of Physics, NTU) 邀請講演 (Id) 科學50 朱國瑞 教授(臺灣大學物理學系)
11:10 – 11:30	*Study on THz Vacuum Electronic Sources Using FDTD PIC Simulations* Invited talk (Ie) Prof. Ming-Chieh Lin (Department of Physics, FJCU) 邀請講演 (Ie) 林銘杰 教授(輔仁大學物理學系)
11:30 – 11:50	*Stable harmonic multiplying gyrotron traveling-wave amplifiers with distributed wall losses and attenuating severs* Invited talk (If) Prof. Yi-Sheng Yeh (Department of Electro-Optical Engineering, STUT) 邀請講演 (If) 葉義生 教授(南台科技大學光電工程學系)
11:50 – 12:00	Group photo session 與會來賓團體照
12:00 – 14:00	Lunch break and poster session P2 午餐及壁報欣賞 P2

Agenda	Venue：Room 019, Physics Building, NTHU
Session III	**THz Sensing and Applications(I)** ***Chair: Prof. K. R. Chu***
14:00 – 14:30	*Development of efficient THz emitter and detector devices for terahertz time-domain spectroscopy* Invited talk (IIa) Prof. Masahiko Tani (University of Fukui) 邀請講演 (IIa) 谷正彥 教授(福井大學)
14:30 – 14:50	*Metamaterials with Multiple Resonances towards Complex Optical Functionalities* Invited talk (IIb) Prof. Ta-Jen Yen (Department of Materials Science and Engineering, NTHU) 邀請講演 (IIb) 嚴大任 教授(清華大學材料科學工程學系)
14:50 – 15:10	*Comprehensive THz spectroscopic study of InN* Invited talk (IIc) Prof. Hyeyoung Ahn(Department of Photonics, NCTU) 邀請講演 (IIc) 安惠榮 教授(交通大學光電工程學系)
15:10 – 15:30	*Terahertz-Pulse Electromagnetic Radiation due to Coherent Phonon-Polariton in <110> ZnTe Crystal* Invited talk (IId) Prof. Cheng-Chung Chi (Department of Physics, NTHU) 邀請講演 (IId) 齊正中 教授(清華大學物理學系)
15:30 – 16:00	Coffee break and poster session P3 茶敘及壁報欣賞 P3
Session IV	**THz Sensing and Applications(II)** ***Chair: Prof. C. W. Luo***
16:00 – 16:30	*Recent Advances in sub-THz Photonic wireless Links with Data Rate beyond 20 Gbit/s* Invited talk (IIe) Prof. Ci-Ling Pan (Department of Physics, NTHU) 邀請講演 (IIe) 潘犀靈 教授(清華大學物理學系)
16:30 – 16:50	*Slow relaxation dynamics of nano-confined water in MCM-41 probed by THz wave spectroscopy* Invited talk (IIf) Prof. Chi-Kuang Sun (Department of Electrical Engineering, NTU) 邀請講演 (IIf) 孫啟光 教授(台灣大學電機工程學系)
16:50 – 17:10	*Generation of Terahertz Radiation from GaAs thin films* Invited talk (IIg) Prof. Kaung-Hsiung Wu (Department of Electrophysics, NCTU) 邀請講演 (IIg) 吳光雄 教授(交通大學電子物理系)
17:10 – 17:30	*The effects of two-photon absorption on terahertz radiation generated by femtosecond-laser excited photoconductive antennas* Invited talk (IIh) Prof. Chao-Kuei Lee (Department of Photonics, NSYSU) 邀請講演 (IIh) 李晁逵 教授(中山大學光電工程學系)
17:30 – 18:00	Panel discussion 兆赫科技論壇

大會演講者簡介

Brief Introduction of the Invited Speakers

Toshitaka Idehara

Research Center for Development of Far Infrared Region

University of Fukui, Japan

一、個人簡歷

Curriculum Vitae

Name	Toshitaka Idehara
Birth day	15/04/1940
Address	4-19-10 Matsumoto, Fukui-shi 910-0003, Japan
Affiliation	Research Center for Development of Far Infrared Region, University of Fukui 3-9-1 Bunkyo, Fukui-shi 910-8507, Japan
Position	Professor, Supervisor of Research,

Education

April 1959	Enter to Faculty of Science, Kyoto University
March 1963	Graduate from Faculty of Science, Kyoto University
April 1963	Enter to Graduate Course of Faculty of Science, Kyoto University
March 1968	Graduate from the above course Doctor Degree (Doctor of Science)

Professional

April 1969	Lecturer, Faculty of Engineering, Fukui University
April 1971	Associate Professor, Faculty of Engineering, Fukui University
June 1990	Professor, Faculty of Engineering, Fukui University
April 1999	Professor, Research Center for Development of Far Infrared Region, Fukui University The First Director of the Research Center (April 1999 – March 2006)
April 2006	Professor, Supervisor of Research, Research Center for Development of Far Infrared Region, University of Fukui February 1985 Visiting Professor, University of California, Davis (till October 1985)
June 2004	Editor in Chief, Former International Journal of Infrared and Millimeter Waves, Present Journal of Infrared, Millimeter and Terahertz Waves (till

December 2010))

April 2005 The president, The Japan Society of Infrared Science and Technology (till March 2007)

Prize

April 2009 Prize for Science and Technology from Minister of Education, Culture, Sports, Science and Technology (MEXT)

Research Subjects

From 1964 to 1976	Negative absorption of electromagnetic waves in plasmas
From 1967 to 1982	Instability of electron cyclotron harmonic waves in electron beam-plasma systems
From 1978 to the present	High frequency harmonic gyrotron development in THz frequency region
From 1995 to the present	Development of high power THz technologies using gyrotrons as radiation sources

二、聯絡方式

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Desktop mW-MW Coherent THz-wave Sources

Yen-Chieh Huang

Department of Electrical Engineering

National Tsing Hua University

一、研究領域簡介

Dr. Huang received his PhD in 1995 from the Electrical Engineering Department, Stanford University, and conducted his postdoctoral research there until January 1997. He then joined the Nuclear Science Department, National Tsinghua University (NTHU) on Taiwan, and in August 1999 he transferred to the Department of Electrical Engineering in the same university. Dr. Huang's research interest is on quasi-phase-matched nonlinear optics and relativistic photonics. He has received a number of awards, including the Outstanding Young Electrical Engineer Award from the Chinese Institute of Electrical Engineering, the Outstanding Young Optical Engineer Award from the ROC Optical Engineering Society, the Outstanding Teaching Award from NTHU, and the Academic-Industry Collaboration Award also from NTHU. He is now actively working on THz difference frequency generation and relativistic electron superradiance.

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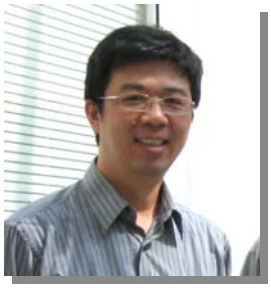
Coherent THz Radiation from Ultrashort Electron Pulses

Wai-Keung Lau

National Synchrotron Radiation Research Center

一、研究領域簡介



Wai-Keung Lau received the M.S. degree in physics from National Central University in 1985 and Ph.D. degree in physics from National Tsing Hua University in 1990.

He is currently an associate scientist in the linac group of National Synchrotron Radiation Research Center. His research interests include high brightness relativistic electron beams, advanced linac technology and free electron lasers.

二、聯絡方式

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Competition between Harmonic Cyclotron Maser Interactions in the Terahertz Regime

Kwo-Ray Chu

Department of Physics

National Taiwan University

一、研究領域簡介

Kwo Ray Chu received the B. S. degree in physics from the National Taiwan University in 1965, the M. S. degree in physics from the University of Massachusetts in 1968, and the Ph. D. degree in applied physics from Cornell University in 1972. His fields of expertise include plasma physics, electrodynamics, and relativistic electronics.

From 1973 to 1983, he was associated with the High Power Electromagnetic Radiation Branch, U. S. Naval Research Laboratory, where he headed the Advanced Concepts Section from 1977 to 1983 to carry out research on coherent electromagnetic radiation generation. Concurrently, he served for 3 years as an Adjunct Associate Professor in the Department of Applied Sciences at Yale University. In 1983, he joined the Physics Department of the National Tsing Hua University in Taiwan, where served as Professor/Distinguished Professor for 27 years. Since August, 2010, he has been a Distinguished Professor of the Physics Department of the National Taiwan University, Taiwan.

He was elected Fellow of the American Physical Society in 1983, Fellow of the IEEE in 1997, and Academician of the Academy of Science of Taiwan in 2002. He was the recipient of the 2001 K.J. Button Medal and Prize of the British Institute of Physics and the Plasma Science and Application Award of the IEEE Nuclear and Plasma Sciences Society.

二、聯絡方式

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Study on THz Vacuum Electronic Sources Using FDTD PIC Simulations

Ming-Chien Lin

NanoScience Simulation Laboratory

Fu Jen Catholic University

一、研究領域簡介

Dr. Ming-Chieh Lin has been with Fu Jen Catholic University, Taiwan, as an assistant professor and the founder of NanoScience Simulation Laboratory (NSSL) at FJU, where he built a homemade 64-bit PC cluster and worked on ab inito calculations of nanomaterials and electromagnetics. He has been with Chung-Shan Institute of Science and Technology (CSIST), Taiwan, where he worked on high power microwave sources and millimeter-wave tubes for many years. He was also with Klystron/Microwave Department, Stanford Linear Accelerator Center (SLAC), as a Visiting Physicist, designing sheet beam klystrons for future linear colliders. He has been with National Center for High-performance Computing (NCHC), Taiwan, as a Postdoctoral Researcher, working on high-performance scientific computing. He has also collaborated with Plasma Theory and Simulation Group (PTSG), University of California, Berkeley, working on electron emission and terahertz (THz) devices for many years as a visiting scholar. He has more than ten years of simulation experience with both the FEM and FDTD PIC methods. He is currently working on 3D finite-difference time-domain particle-in-cell simulations of plasmas, microwave tubes, field emission, and photonic crystals, and also consulting on some advanced designs. His research interests include high-power microwave physics, THz devices, photonic crystals, nano-semiconductors, electron emission mechanisms, ab initio calculations, and parallel computations.

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Stable harmonic multiplying gyrotron traveling-wave amplifiers with distributed wall losses and attenuating severs

Yi-Sheng Yeh

Department of Electro-Optical Engineering

Southern Taiwan University

一、研究領域簡介

Yi Sheng Yeh received his B.S. degree from National Tsing Hua University in 1985 and his M.S. and Ph.D. degrees from National Cheng Kung University in 1987 and National Tsing Hua University in 1997, respectively. Upon graduation, he is an Associate Professor with the Department of Electric Engineering, Southern Taiwan University of Technology. He is currently a Professor with the Department of Electro-Optical Engineering, Southern Taiwan University, Taiwan. From 1997 to 2001, his research focuses on the design of the magnetron injection gun (MIG). From 2002 to 2011, his research focuses on the design and analysis of the high-power gyro-TWT and the gyro-BWO. His current research focuses on the analysis of the Harmonic Multiplying gyro-TWT.

二、聯絡方式

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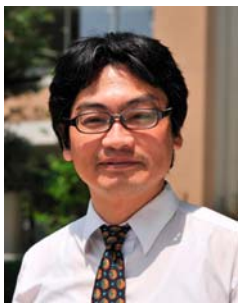
Development of efficient THz emitter and detector devices for terahertz time-domain spectroscopy

Masahiko Tani

Research Center for Development of Far-Infrared Region

University of Fukui, Japan

一、研究領域簡介



Masahiko Tani is Professor of Research Center for Development of Far-Infrared Region, University of Fukui (FIR FU), Japan. He serves Terahertz Technology Forum, Japan, as the Chair of Research Exchange Committee. He is Technical Advisor of AISPEC, a venture company producing THz spectrometers. Prof. Tani worked at Kansai Advanced Research Center, Communications Research Laboratory (National Institute of Information and Communications Technology at present), Japan, from 1992 to 2002. Tani taught at Osaka University, Japan, from 2002 to 2008. He has been holding visiting professorship at Osaka University from 2008. In the past decade, the main foci of Prof. Tani's research activities have been THz spectroscopy of organic and biological molecules, and development of spectroscopic techniques for this purpose, including developments of a high-performance THz time-domain spectrometer and THz time-domain coherent Raman spectroscopy, etc. Prof. Tani is a member of OSA, IEEE Photonics Society, Japan Society of Applies Physics, Physical Society of Japan, Spetroscopical Society of Japan.

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Metamaterials with Multiple Resonances towards Complex Optical Functionalities

Ta-Jen Yen

Department of Materials Science and Engineering

National Tsing Hua University

一、研究領域簡介

Ta-Jen Yen is an associate professor at Department of Materials Science and Engineering, and the Director of Student Extracurriculum Activity, National Tsing Hua University (NTHU), Hsinchu, Taiwan. Prof. Yen's main research activities include Electromagnetic Metamaterials, Plasmonics, Biophotonics and Photovoltaics. His recent publications of THz artificial magnetism and Si micro fuel cells are ones of the most cited papers in the corresponding fields.

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Comprehensive THz spectroscopic study of InN

Hyeyoung Ahn

Department of Photonics

National Chiao Tung University

一、研究領域簡介

Hyeyoung Ahn is an associate professor of photonics at National Chiao-Tung University (NTCU), Hsinchu, Taiwan. The main research interests have been focused on the ultrafast optical and terahertz spectroscopy of semiconductors including their nanostructures. The recent studies include terahertz generation from narrow band semiconductors, time-domain terahertz spectroscopy of InN epitaxial films and nanostructures (nanorods and naonodisks), ultrafast carrier dynamics of semiconductors probed by optical and terahertz pulses, time-resolved photoluminescence study of InGaN nanostructures, and optical spectroscopy of light emitting nanomaterials coupled with optical or plasmonic microcavities.

二、聯絡方式

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Terahertz-Pulse Electromagnetic Radiation due to Coherent Phonon-Polariton in <110> ZnTe Crystal

Cheng-Chung Chi

Department of Physics

National Tsing Hua University

一、研究領域簡介

Dr. Cheng-Chung John Chi obtained his BS in Physics from the National Taiwan University (1970), and his Ph.D. in Physics from the University of Pennsylvania (1976). After two and half years (1976/8 to 1979/2) of postdoctoral research at UC Berkeley with Professor John Clarke, he joined T.J. Watson Research Center of IBM as a research staff member. During the fourteen and half years (1979/2 to 1993/7) with IBM, Dr. Chi broadened his research spectrum and engaged in many research as well as management work. In 1993, Dr. Chi returned to Taiwan and became a professor of the Physics Department of the National Tsing Hua University, which is still his current position. The managerial positions that he has had include Director of Materials Science Center (1995/8 to 1998/7), Director of Physics Research Promotion Center of NSC (1998/8 to 1999/7), Chairman of the Physics Department (1999/8 to 2002/7), Vice President (1998/1 to 2000/1) and President (2000/1 to 2002/1) of the Physical Society of Republic of China, Director of Nano Technolgy and MEMS Center (2004/8 to 2006/7), Center for Nano Science and Technology, University System of Taiwan (2003/5 to present).

Dr. Chi's research interests include physical properties of superconductors, transition metal oxides, and graphene related materials. The experimental techniques that he has employed for his research include electrical transport, STM and Scanning SQUID, ultrafast laser and Tera Hertz measurements and applications. He has published more than 180 scientific journal papers and edited two conference books. The research topics of superconductivity includes: high temperature superconducting materials and mechanism, correlation of superconductivity and magnetism, superconducting devices such as SIS mixers and SQUIDs, transition metal oxides, development of Scanning SQUID probe and Scanning SQUID and Tunneling Microscope. The research topics of ultrafast laser measurements include: ultrafast photoconductive switch, Tera Hertz pulse generation and detection, time-resolved THz spectroscopy, photonic waveguides and devices, using various ultrafast pump-probe techniques to study superconducting oxides and other materials, PL, PLE and Raman spectroscopy techniques.

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Recent Advances in sub-THz Photonic wireless Links with Data Rate beyond 20 Gbit/s

Ci–Ling Pan

Department of Physics

National Tsing Hua University

一、研究領域簡介

Ci-Ling Pan is Tsing Hua Chair Professor, Chairperson of the Department of Physics and Institute of Astronomy, National Tsing Hua University (NTHU), Hsinchu, Taiwan. He also held joint appointment at the Institute of Photonics Technologies and served as Director of the Photonics Research Center of NTHU. Prof. Pan taught at National Chiao Tung University, Taiwan, 1981-2009. He also held visiting professorship at Osaka University and Chinese University of Hong Kong in 2004 and 2008, respectively. In the past decade, the main foci of Prof. Pan's research activities have been Ultrafast and THz Photonics. Recent research highlights include developments of functional liquid crystal THz photonic devices, femtosoeocnd-laser recrystallization and activation of silicon as well as novel THz generators and detectors. The latter were used in diverse applications such as diagnostics of technologically important materials for photovoltaics, assessing burn trauma and very high-data-rate wireless communication Link at 100 GHz or 0.1 THz. Prof. Pan is a Fellow of OSA, SPIE, PSROC and APS.

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Slow relaxation dynamics of nano-confined water in MCM-41 probed by THz wave spectroscopy

Chi-Kuang Sun

[1] *Graduate Institute of Photonics and Optoelectronics and Department of Electrical Engineering, National Taiwan University*

[2] *Molecular Imaging Center, National Taiwan University*

一、研究領域簡介

Chi-Kuang Sun was born in Tainan, Taiwan, in 1965. He received the B.S. degree in electrical engineering from National Taiwan University, Taipei, in 1987 and the M.S. and Ph.D. degrees in applied physics from Harvard University, Cambridge, MA, in 1990 and 1995, respectively.

He was a Visiting Scientist at the Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, MA, between 1992 and 1994, working on femtosecond carrier dynamic studies of semiconductors and metals. He was with the NSF Center of Quantized Electronics Structures (QUEST), University of California, Santa Barbara, CA, from 1995 to 1996 as an assistant research engineer, conducting research on quantum dots, GaN, microcavity, high speed communication devices and systems. In 1996, he joined the Graduate Institute of Photonics and Optoelectronics and Department of Electrical Engineering at National Taiwan University (NTU), Taipei, Taiwan, where he is now a life distinguished professor. He currently serves as the Associate Dean of College of Electrical Engineering and Computer Science and the Chief Director of Molecular Imaging Center, National Taiwan University. He is an adjunct research fellow at the Institute of Physics and Research Center for Applied Sciences, Academia Sinica, Taipei, Taiwan since 2010 and 2006, respectively. He leads the NTU Ultrafast Optics Group and his research interest is primarily concerned with nano-acoustics, femtosecond laser technology, THz optoelectronics, and biomedical optics.

Dr. Sun is a fellow of the Optical Society of America, a fellow of the International Society for Optical Engineering (SPIE), and a fellow of the IEEE Photonics Society. He was the recipient of year 2000 C.N. Yang Outstanding Young Researcher Award from Association of Asian Pacific Physical Society, the 2001 Academia Sinica Research Award for Junior Researchers from Academia Sinica of Taiwan, the 2003 Leica Microsystems Innovation Award, the MERIT Award from the National Health Research Institute of Taiwan (2003-2009; 2010), the 2004 NTU Research Achievement Award, the Outstanding Research Award (2004-2006; 2009-2012) and the Outstanding Research Grant Award (2008-2011) from National Science Council of Taiwan, the 2008 Y. Z. Hsu Scientific Paper Award, the 2008 Outstanding Electrical Engineer Award from the Chinese Institute of Electrical Engineering, and the 2010 Engineering Medal from the Taiwan Photonic Society.

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Generation of Terahertz Radiation from GaAs Thin films

Kaung-Hsiung Wu

Department of Electrophysics

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一、研究領域簡介

1. Surface physics
2. High-temperature superconductivity device and physics
3. Laser engineering and physics
4. Laser coating and vacuum system
5. Ultrafast time-domain spectroscopy

二、聯絡方式

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The effects of two-photon absorption on terahertz radiation generated by femtosecond-laser excited photoconductive antennas

Chao-Kuei Lee

Department of Photonics

National Sun-Yat-Sen University

一、研究領域簡介

Chao-Kuei Lee received his PhD degree of Electro-Optical engineering from National Chiao Tung University, Taiwan, in 2003. Prof. Lee joined National Sun Yat-sen University as associate Professor in 2004. He is currently an associate professor who directs the laboratory of Femtosecond & Quantum Modulation with the Department of Photonics. His research interests focus on ultrafast photonics, including generating and characterizing ultrafast photonic signals with pulse shaping technique.

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Session I (Ia)

High power THz radiation sources developed in FIR FU - Gyrotrons FU and FU CW Series

Toshitaka Idehara
Research Center for Development of Far Infrared Region
University of Fukui, Japan

Abstract

Powerful sources of coherent radiation in the sub-terahertz and in the terahertz frequency range of the electromagnetic spectrum are necessary for a great and continuously expanding number of applications in the physical research and in various advanced technological processes as well as in radars, communication systems, for remote sensing and inspection etc.. In recent years, a spectacular progress in the development of various gyro-devices and in particular of the powerful high frequency (sub-terahertz and terahertz) gyrotron oscillators has demonstrated a remarkable potential for bridging the so–called terahertz power gap and stimulated many novel and prospective applications. In this presentation we outline two series of such devices, namely the Gyrotron FU Series which includes pulsed gyrotrons and Gyrotron FU CW Series which consist of tubes operated in a CW (continuous wave) or long pulse mode, both developed at the FIR FU Center. In addition, we present several other gyro-devices developed as terahertz radiation sources. We present the most remarkable achievements of these devices and illustrate their applications by some characteristic examples. An outlook for the further extension of the Gyrotron FU CW Series is also provided.

Desktop mW-MW Coherent THz-wave Sources

Yen-Chieh Huang

Department of Electrical Engineering

National Tsing Hua University

Abstract

I will present a desktop MW-power free-electron laser (FEL) at THz frequencies in the superradiant regime. By using some nominal beam parameters from an S-band THz-pulse-train electron gun, we show in theory and simulation that 10-MW-level radiation power at THz frequencies is achievabe from a sub-meter long undulator in one single electron transit through the undulator. The proposed THz superradiance FEL is directly attached to the emittance compensating coil of the S-band photoinjector without using any additional beam-fucusing element in between. This compact design allows the construction of a 10-MW FEL at THz frequencies on an ordinary desk. We will also show the usefulness of a tapered undulator for a such superradiance FEL. With a 20% linearly tapered undulator, the FEL radiation power can be increased by more than 30%. The coherence of the FEL is assured by a THz-wave seed source from an optical nonlinear frequency mixer. This THz-wave seed source is capable of generting mW level THz-wave radiation with a MHz linewidth. If time allows, I will report several experimentally demonstrated narrow-line low-power THz-wave sources based on nonlinear optical techniques.

Session I (Ic)

Coherent THz Radiation from Ultrashort Electron Pulses

W.K. Lau[1], A.P. Lee[1], J.Y. Hwang[1], N.Y. Huang[2]

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Abstract

A test linac equipped with thermionic cathode rf gun is being built at NSRRC for development of high brightness technology. It is a 15-30 MeV S-band linac designed for the generation of ultrashort relativistic electron beam by rf bunch compression in the linac accelerating structure. With the aid of a collimator in the alpha magnet as beam selector, high brightness sub-hundred femtosecond electron pulses with bunch charge of about 30 pC can be produced from this facility. This beam can be used to produce coherent THz spontaneous radiations from undulators. Status of the installation of this test linac as well as a preliminary calculation of the coherent undulator emission characteristics will be reported.

Session II (Id)

Competition between Harmonic Cyclotron Maser Interactions in the Terahertz Regime

S. H. Kao[1,2], C. C. Chiu[1], K. F. Pao[1], and K. R. Chu[1]

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Abstract

Cyclotron harmonic interactions are a key physics issue of critical importance to the generation of terahertz radiation via the electron cyclotron maser instability for practical magnetic field strengths. We present an inherent mechanism, as well as a deciding factor, which governs the competition between low- and high-harmonic interactions. Multimode simulations reveal the physical process in which a significant advantage develops for the lower-harmonic interaction, which eventually dominates in the fully nonlinear stage. The results also suggest a start-up scenario for persistent higher-harmonic operation.

Session II (Ie)

Study on THz Vacuum Electronic Sources Using FDTD PIC Simulations

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Abstract

Terahertz (THz) waves, i.e., electromagnetic radiation in the frequency range extending from 0.1 to 10 THz (wavelengths of 3 mm down to 0.03 mm), have been used to characterize the electronic, vibrational, and compositional properties of solid, liquid, and gas phase materials during the past decades. More and more applications in imaging science and technology call for the well development of THz wave sources, especially in high power regime. On the other hand, amplification and generation of a high frequency electromagnetic wave are a common interest of field emission based devices. Therefore, we have proposed a vacuum electronic device based on field emission mechanism for the generation of THz waves. To verify our thinking and designs, the cold tests and the hot tests have been studied via the simulation tools, SUPERFISH and MAGIC, respectively. In the hot tests, the simulation results show that an electronic efficiency up to 4% can be achieved without employing any magnetic circuits. The interaction mechanism has been studied and understood. The progress of the related research work will be discussed and new finite-difference time-domain particle-in-cell simulation tools will be introduced.

* This project is supported by National Science Council (Grand No. NSC 96-2112-M-030-004-MY3), NCTS, and NCHC.

Session II (If)

Stable harmonic multiplying gyrotron traveling-wave amplifiers with distributed wall losses and attenuating severs

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Abstract

Harmonic multiplying gyrotron traveling-wave amplifiers (gyro-TWTs) provide the magnetic field reduction and frequency multiplication. However, spurious oscillations may reduce the amplification of the gyro-TWT. Most structures with distributed wall losses are stabilized in gyro-TWTs that operate at low beam currents. Attenuating severs are added to the interaction circuit of a distributed-loss gyro-TWT to prevent high beam currents that result in mode competition. This study proposes Ka-band and W-band harmonic multiplying gyro-TWTs operating at lower-order modes to avoid the fundamental harmonic absolute instabilities. By amplifying a TE11 (s=1) drive wave, the second harmonic component TE21 (s=2) of the beam current initiates a wave to be amplified. A nonlinear self-consistent code, based on a slow time scale formulation, is developed to evaluate the performance of stable gyro-TWT amplifier. The Ka-band and W-band harmonic multiplying gyro-TWTs are predicted to yield a peak output power of 230 kW at 33.65 GHz with an efficiency of 30% and 100 kW at 98 GHz with an efficiency of 22.5%, respectively. This work was supported by the National Science Council under Contract No. NSC 99-2221-E-218 -009.

Session III (IIa)

Development of efficient THz emitter and detector devices for terahertz time-domain spectroscopy

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Abstract

Terahertz time-domain spectroscopy (THz-TDS) is a powerful spectroscopic tool for investigation of material properties in the THz frequency region (0.1-10 THz or 3-300 cm^{-1}). THz-TDS is also applicable to spectroscopic imaging, in which THz spectroscopic features of constituent materials in the imaging target can be utilized to make the imaging contrast. Since THz radiation has relatively good transmissions in many dielectric materials, see-through imaging is possible, which is strongly desired in quality control of many industrial products, including medical tablets. In the industrial applications, however, the efficiency (or signal-to-noise ratio, in other words) and measurement speed are important issues as well as the system cost. Therefore, development of efficient THz emitter and detector, as well as a fast time-domain scanning technique, is a key issue for industrial applications of THz-TDS. In line with this, we have developed several semiconductor or electro-optic devices as the efficient THz emitters and detectors. In addition, we also developed an ultrafast time-domain sampling technique, which is based on a modulation of the repetition frequency of a femtosecond laser used in THz-TDS. In this paper we summarize recent our research and development of these devices and sampling technique. The topics to be presented in the workshop include:

1. THz emission from InSb and InAs surface enhanced with magnetic field and lens coupling,
2. THz detection with a photoconductive antenna on low-temperature-grown GaAs and 1.55-μm probe pluses,
3. Cherenkov-phase matched EO sampling with $LiNbO_3$ crystal coupled with a Si-prism, and
4. Asynchronous optical sampling using a repetition frequency tunable femtosecond laser.

Metamaterials with Multiple Resonances towards Complex Optical Functionalities

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Abstract

Metamaterials attract much attention owing to their notable electric or magnetic properties, which originated from their specially designed architecture rather than their constitutive compositions. Herein, we successfully delivered a metamaterial that enables right- and left-handed passbands in the microwave region. Following this work, we further experimentally demonstrated metamaterial-based ultrabroad bandpass filters in the 60-GHz band for the high-speed wireless transport and even in the special terahertz-gap region for terahertz optical systems by engineering the multiple resonances of the metamaterials. Resting on this concept, metamaterials with multiple resonances possess considerable potential for complex and powerful optical devices in the future.

Session III (IIc)

Comprehensive THz spectroscopic study of InN

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[2]*Department of Physics, National Tsing Hua University*

Abstract

Terahertz time-domain spectroscopy (THz-TDS) has been used to investigate terahertz dispersion relation of Mg-doped InN (InN:Mg) film. Mg-doping in InN was found to significantly increase terahertz transmittance. THz-TDS analysis based on the Drude model shows that this high transmittance from Mg-doped InN is mainly due to the reduction in mobility associated with ionized dopants. The Hall-effect-measured mobility is typically lower than the THz-TDS-measured mobility for the same samples. However, the results of both measurements have the same slope in the linear relation between mobility and density. By introducing a comprehensive ratio of ~0.2, an excellent agreement in mobilities of two methods is obtained.

Terahertz-Pulse Electromagnetic Radiation due to Coherent Phonon-Polariton in <110> ZnTe Crystal

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Abstract

Typical terahertz-pulse electromagnetic radiation generated from a <110> ZnTe crystal excited by ultrafast optical laser pulses through optical rectification (OR) effect consists of a few-cycle oscillations in real time with a duration comparable to the laser pulse width. However, we demonstrate that coherent phonon-polariton in the ZnTe crystal can strongly affect the shape of the generated terahertz pulses under appropriate conditions; a long damped oscillation tail following the main pulse can be observed. The oscillation can last a few tens of picoseconds and its Fourier transform shows a higher and narrower frequency peak than that of the main pulse. We demonstrate that the generations of the oscillation tail depends on the duration of laser pulse and its wavelength. In addition, we have also performed theoretical calculations based upon the OR effect coupled with the phonon-polariton mode and obtained theoretical pulse shape in good agreement with our experimental observation.

Session IV (IIe)

Recent Advances in sub-THz Photonic wireless Links with Data Rate beyond 20 Gbit/s

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Abstract

To meet the rapidly growing demand of gigabits wireless access applications, sub-THz or millimeter wave (MMW) carriers in W-band (75-110 GHz) or above are essential for obtaining the necessary broad transmission bandwidth. Thanks to the almost unlimited bandwidth and very low propagation loss in optical fiber, an efficient and cost-effective way to distribute synchronized photonic MMW signals from the central office to multiple base stations is a radio-over-fiber (RoF) communication system. In this paper, we will review our recent work on Photonic Wireless communication Link at 100 GHz or 0.1 THz. Key technologies are photonic MMW sources and photonic MMW transmitters. Wireless data transmission at a data rate as 20-Gb/s via bias modulation of such novel device has been successfully realized. We have also demonstrated an optical ultra-wide band Impulse-Radio Fiber-to-the-antenna (UWB-IR FTTA) system for in-building and in-home applications, operating from 75 to 110 GHz. Both downstream and upstream high data rate communications in the W-band were possible. By spectral line-by-line pulse shaping, it is also possible to photonically generate MMW signals with power exceeding that of the sinusoidal modulation scheme by 7.4 dB.

Session IV (IIf)

Slow relaxation dynamics of nano-confined water in MCM-41 probed by THz wave spectroscopy

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[2]*Molecular Imaging Center, National Taiwan University*

[3]*Department of Chemistry, National Taiwan University*

Abstract

Water existing in a nano-confined environment exhibits extremely different structures and dynamics from bulk water. Several measuring techniques and materials have been adopted to investigate the nano-confined water. However, investigation of only few water monolayers is rarely explored due to the unsuitable material model or the restricted sensitivity of measuring systems. Here, we use a well-characterized nanoporous material, mobil composition of matter number 41 (MCM-41), as the water adsorbent to mimic the biologically and chemically confining environments. Due to the uniform nano-channel matrices and well-characterized water adsorption-desorption isotherms, the nano-confined water in the nano-channel matrices is ensured to form exclusively two states: surface-adsorbed water state and capillary condensed water state. Since it is well known that the THz waves are extremely sensitive to the water dynamics, we have utilized the THz time-domain spectroscopy (THz-TDS) to probe the relaxation dynamics of nano-confined water which are extracted via the dual Debye relaxation model. The main Debye relaxation dynamics of the capillary condensed water in nano-channels with the pore size of 1.5 and 2.4 nm are observed to slower than that of bulk water. Our result shows that the confining effect plays a key role in reducing the mobility of capillary condensed water. On the other hand, the surface-adsorbed water in two nano-channels exhibits different features. In 1.5-nm nano-channels, the surface-adsorbed water behaves the same as bulk water while in 2.4-nm nano-channels, the relaxation dynamics of surface-adsorbed water are extremely slowed. The difference may be attributed to the geometry of the nano-channels. In smaller pores, the surface forces are weakened due to the large curvature so that the surface-adsorbed water can possess higher mobility than that in larger pores.

Generation of Terahertz Radiation from GaAs Thin films

J. J. Lee[1], H.-J. Chen[1], C. W. Luo[1], T. M. Uen[1] , J. Y. Juang[1] , J.-Y. Lin[2], and K. H. Wu[1] *

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2 Institute of Physics, National Chiao Tung University, Hsinchu 300, Taiwan

Abstract

Pure (00l)-oriented GaSe thin films with various thicknesses have been prepared on Si(111) by pulsed laser deposition. The characteristics of these films were examined by x-ray diffraction θ-2θ, ω and φ scans, Raman spectroscopy, and Hall measurement. The GaSe thin films were excited by femtosecond laser pulses to generate terahertz (THz) radiation. We found that the characteristics of the THz radiation generated by GaSe films are significantly different from that generated by GaSe single crystals. The possible mechanisms for such differences are proposed.

This project is financially sponsored by the National Science Council (grant no. NSC 98-2112-M-009-006-MY3) and the Ministry of Education (2009 MOE ATU program at NCTU) of Taiwan, R.O.C.

The effects of two-photon absorption on terahertz radiation generated by femtosecond-laser excited photoconductive antennas

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[2]*Department of Physics, National Tsing Hua University*

Abstract

Terahertz (THz) radiation can be generated more efficiently from a low-temperature-grown GaAs (LT-GaAs) photoconductive (PC) antenna by considering the two-photon absorption (TPA) induced photo-carrier in the photoconductor. A rate-equation-based approach using the Drude-Lorentz model taking into account the band-diagram of LT-GaAs is used for the theoretical analysis. The use of transform-limited pulses at the PC antenna is critical experimentally. Previously unnoticed THz pulse features and anomalously increasing THz radiation power rather than saturation were observed. These are in good agreement with the theoretical predictions. The interplay of intensity dependence and dynamics of generation of photoexcited carriers by single-photon absorption and TPA for THz emission is discussed.

壁報論文簡介

Abstracts of Posters

編號	壁報論文題目	作者	指導教授	單位
01	Photonic Synthesis of chirped MMW generation using optical shaped pulses and a photonic transmitter	Jim-Wein Lin, Chun-Liang Lu, Jin-Wei Shi, Chen-Bin Huang, Ci-Ling Pan	Ci-Ling Pan	Department of Physics, NTHU
02	The Complex Refractive Indices of the Liquid Crystal Mixture E7 in the Terahertz Frequency Range	Chan-Shan Yang , Chia-Jen Lin, Ru-Pin Pan, Christopher T. Que, Kohji Yamamoto, Masahiko Tani Ci-Ling Pan	Ci-Ling Pan	Department of Physics, NTHU
03	Effects of Two-Photon Absorption on Terahertz Radiation Generated by Femtosecond-laser Excited Photoconductive Antennas	Chao-Kuei Lee, Chan-Shan Yang, Sung-Hui Lin, Shiuan-Hua Huang, Osamu Wada Ci-Ling Pan	Ci-Ling Pan	Department of Physics, NTHU
04	Terahertz Dielectric Response and Optical Conductivity of ITO Nanowhiskers	Chan-Shan Yang, Chia-Hua Chang , Mao-Hsiang Lin, Peichen Yu, Ci-Ling Pan	Ci-Ling Pan	Department of Physics, NTHU
05	Correlation of the measured and calculated terahertz waveforms as the determination of optical properties of the dielectric	Rone Hwa Chou, Ci-Ling Pan	Ci-Ling Pan	Department of Physics, NTHU
06	A Self-Asynchronous Optical Sampling Scheme for Rapid–Scan THz-TDS Systems	Takashi Furuya, Elmer Estacio, Christopher Que, Kazuki. Horita, Kohji Yamamoto, Fumiaki Miyamaru, Seizi Nishizawa , Masahiko Tani	Masahiko Tani	FIR Center University of Fukui, Fukui, Japan

編號	壁報論文題目	作者	指導教授	單位
07	Efficient Generation and Electro-Optic Sampling Detection of Intense THz Radiation using Cherenkov Phase-Matching Scheme in a LN Crystal Coupled to a Si Prism	Kazuki Horita, Tetsuya Kinoshita, Christopher T. Que, Elmer S. Estacio, Michael I. Bakunov, Koji Suizu, Kodo Kawase, Kohji Yamamoto, Masahiko Tani	Masahiko Tani	FIR Center University of Fukui, Fukui, Japan
08	Enhancement of Terahertz Emission from InSb Using Both Magnetic Field and Lens Coupler Enhancement Methods	Hidekazu Nakajima, Christopher T. Que, Elmer Estacio, Kohji Yamamoto, Masahiko Tani	Masahiko Tani	FIR Center University of Fukui, Fukui, Japan
09	Superfocusing Effect using V-Groove Metallic Structure for Terahertz wave	Satoshi Tsuzuki, Kazuyoshi Kurihara, Fumiyoshi Kuwashima, Takashi Furuya, Christopher T. Que, Elmer Estacio, Kohji Yamamoto, Masahiko Tani	Masahiko Tani	FIR Center University of Fukui, Fukui, Japan
10	CAD of Magnetron Injection Guns for Sub-Terahertz Gyrotrons	J. C. Mudiganti, T. Idehara, Y. Tatematsu, T. Saito, I. Ogawa	T. Idehara	FIR Center University of Fukui, Fukui, Japan
11	Forward and backward THz-wave difference frequency generations from a rectangular nonlinear waveguide	Yen-Chieh Huang, Tsong-Dong Wang, Yen-Hou Lin, Ching-Han Lee, Ming-Yun Chuang, Yen-Yin Lin, Fan-Yi Lin	Yen-Chieh Huang	Institute of Photonics Technologies, NTHU
12	Length dependence of THz difference-frequency generation with strong idler absorption	Yen-Chieh Huang, Tsong-Dong Wang, Ming-Yun Chuang, Yen-Yin Lin, Fan-Yi Lin	Yen-Chieh Huang	Institute of Photonics Technologies, NTHU

編號	壁報論文題目	作者	指導教授	單位
13	High-profile bandpass terahertz filters by hybridizing multiple resonances mode in a monolithic metamaterials	Ting-Tso Yeh, Simone Genovesi, Agostino Monorchio, Enrico Prati, Filippo Costa, Ta-Jen Yen	Ta-Jen Yen	Department of Materials Science and Engineering, NTHU
14	An ultrabroad terahertz bandpass filter based on multiple-resonance excitation of a composite metamaterial	Yi –Ru Jiang	Ta-Jen Yen	Department of Materials Science and Engineering, NTHU
15	Developing A High Power Terahertz Wave Source: A 400GHz 4th Harmonic Gyrotron	C. H. Du, N. C. Chen, C. P. Yuan, T. H. Chang	T. H. Chang	Department of Physics, NTHU
16	Analysis of Positive and Negative Superluminality in Fabry-Pérot-like Interferometers	H. Y. Yao, N. C. Chen, T. H. Chang	T. H. Chang	Department of Physics, NTHU
17	MODAL ANALYSIS FOR METAL-STUB PHOTONIC CRYSTAL IN A PARALLEL-PLATE WAVEGUIDE	C. P. Yuan, T. H. Chang	T. H. Chang	Department of Physics, NTHU
18	Efficient heating with a controlled microwave field	Eric Chao, T. H. Chang	T. H. Chang	Department of Physics, NTHU
19	Broadband excitation of coaxial TE01 mode for multi-channel system at low terahertz	N. C. Chen, T. H. Chang	T. H. Chang	Department of Physics, NTHU
20	Radio-over-Fiber and Fiber-to-the-Antenna Systems using THz	P. H. Huang, C. H. Yeh, C. W. Chow	C. W. Chow	Institute of Photonics Technologies, NCTU

主辦單位簡介

Brief Description of the Sponsoring Organization and University

國立清華大學 物理學系

系所沿革

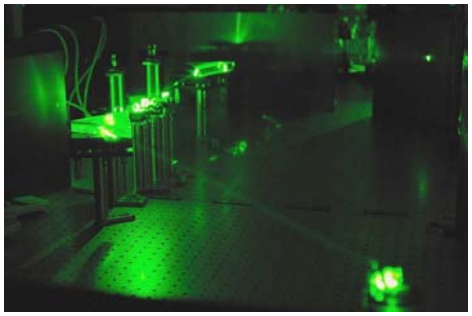
國立清華大學於民國前一年(西元 1910 年)在北平建校，民國 45 年(1956 年)在台灣新竹市復校。首先成立原子科學研究所，物理組為其中一個重要的部門，並開始招收碩士班研究生，為本校日後的物理系及物理研究所奠下良好的基礎。

物理學系則於民國 54 年(1965 年)正式成立，開始招收大學部學生，次年成立物理研究所，招收碩士班研究生；隨即於民國 56 年(1967 年)開始招收博士班研究生。迄今已有約 1500 位學士、850 位碩士及 150 位博士畢業生，歷屆畢業系友於國內外學術界及工業界皆有出色的表現；其中榮任中研院院士共有七位之多，為國內擁有院士榮銜人數最多、密度最高之系所。

民國 90 年(2001 年)於物理系組織內成立天文所，開始招收碩士班研究生，並將於民國 97 年(2008 年)設立天文所博士班。目前全系大學部學生 287 位、碩士班研究生 122 位及博士班研究生 115 位。

師資

本系現有專任教授 34 位(含天文所 5 位)，張石麟、沈元壤、徐遐生、崔章琪、朱經武、朱國瑞等五位院士為本系榮譽講座教授，另有 14 位合聘教授。研究領域遍及統計及數學物理、重力與天文物理、粒子物理與場論、原子核物理、原子分子與光學物理、凝體物理、奈米物理、生物物理、流體與離子體物理等多個學門領域，並有應用科學與跨學門物理。歷年來更有多位教授分別榮獲總統獎、國科會傑出研究獎、教育部學術獎、中山學術獎、教育部講座教授、李遠哲傑出人才基金會講座等等國內



重要學術研究獎項。根據國科會統計資料，國科會傑出研究獎自設立以來，三分之一以上的物理獎得主為本系教授。

本系每位教授皆擔任導師，對學生的課業及日常生活給予適當輔導，並幫助解決問題。平均每八名學生即有一位導師，師生接觸及溝通之機會多，關係密切且融洽。

特色

物理系所自成立以來，一直是教學與研究並重，在教學方面，本系的特色是課程領域涵蓋廣泛，使大學部學生及研究生能充分地按照個人興趣學到各重要的課程，老師們授課也多以嚴謹著稱 。在研究方面，從基礎物理到應用物理的各種物理研究領域都有涵括。近年來「遠見」及「天下」雜誌對國內物理系作過一系列教學與研究評鑑，本系均名列榜首。

國科會物理研究推動中心於 1965 年設立於清華大學物理系，主要任務為負責全國物理研究之策劃及推動工作，並成立物理推動中心圖書館，提供完善圖書服務，為全國物理學界利用。

國家理論科學研究中心於民國八十六年成立於清大，許多教授與研究生積極參與並協助中心之學術活動與交流，促進優良研究風氣，主導國內理論物理研究。

國立清華大學 光電研究中心

成立宗旨

近年來光電相關產業為政府所推動的另一個重點產業並列為十大新興產業之一，世界各國亦積極地投入大量的財力與人力進行材料與產品的開發，本中心將配合國家光電產業之發展，整合產、學、研界，期許開發具有商業化價值之技術及材料，提供給國內業者應用，並藉由中心之計畫進行人才培育，使光電產業能更加穩固且茁壯。

目標展望

1.整合光電領域相關的資源
2.建立核心設施
3.技術研發、專利申請
4.技術移轉/授權
5.產學研聯盟
6.專業人才培育

光電科技為新興之科技，是台灣成長最快，規模最大的新興高科技產業，又是一個跨足物理、化學、材料、電子、微系統、奈米科技、生醫量測，本中心將整合本校在 光電領域相關的資源，推動整合型的計畫，如 Silicon Photonics 新興的光電應用科技，電射顯示技術，半導體照明，太陽能光電，生醫光電，奈米光電，以爭取更多研發資源，同時加強產學研合作，創造出最 有價值及影響力的研究。

兆赫波光電研究團隊

兆赫波 (Terahertz Radiation, 1 THz = 1012 Hz) 是頻率從約 0.1 – 10 THz 範圍內的電磁波的簡稱。此一頻率範圍內的電磁波與物質交互作用的相關研究具有豐富的科學內涵和廣泛的應用前景。邁入二十一世紀後，兆赫科技被世界各國視為重要的前沿領域，其進展使遠紅外領域的科學研究豁然開朗；更促進了如國土安全、遙測、生醫、製程控制與材料分析、造影與通訊等跨研究領域課題有了突破性的面貌。

本中心的宗旨是從事兆赫波與物質交互作的基礎研究，並經由掌握兆赫波的產生、偵測與操控而發展各種應用。主要成員包括潘犀靈、黃衍介、張存續、嚴大

任等，相關教師有齊正中、施宙聰、黃承彬等。本中心也邀集了國內從事兆赫科技研究的頂尖學者：孫啟光（台大）、許晉瑋（中大，國科會吳大猷獎）、趙如蘋（交大）、鄒志偉（交大，國科會吳大猷獎）等參加，也與多個國際團隊有進行中的合作研究。

最新研究成果

物理系潘犀靈教授

過去的五年間，潘犀靈教授研究團隊曾報導了偵測頻寬超越 30 THz 之 GaAs:As+及 InP: H+光導天線，這是迄今利用離子佈植半導體製作之最高頻寬的 THz 偵測器，曾被用以展示第一個直接調制的 THz 通訊系統、傷燙傷偵測系統（台、美專利；與工研院合作）。本團隊也發展了高功率和高效率的次兆赫光子發射器（與中大許晉瑋教授合作），用於超寬帶脈碼無線通信，已可在 W 頻段（0.1 THz）以 20Gb/s 數率傳輸。本團隊也開創了液晶 THz 光子學領域（與交大趙如蘋教授合作），發展多項功能性液晶兆赫光電元件（台、美專利多件）。

光電所黃衍介教授

黃衍介教授研究團隊曾發展最低閥值的兆赫波光參數振盪器。展示超輻射自由電子雷射概念，並獲得相關之美國專利。

材料系嚴大任教授

嚴大任教授曾於 2004 年時，率先利用人工磁性之超穎材料將磁性響應由微波波段推至 Terahertz 的高頻範圍，成果果發表於國際知名期刊 Science ，該文是兆赫科技領域 2004 年發表之論文中迄今被引用作多的。

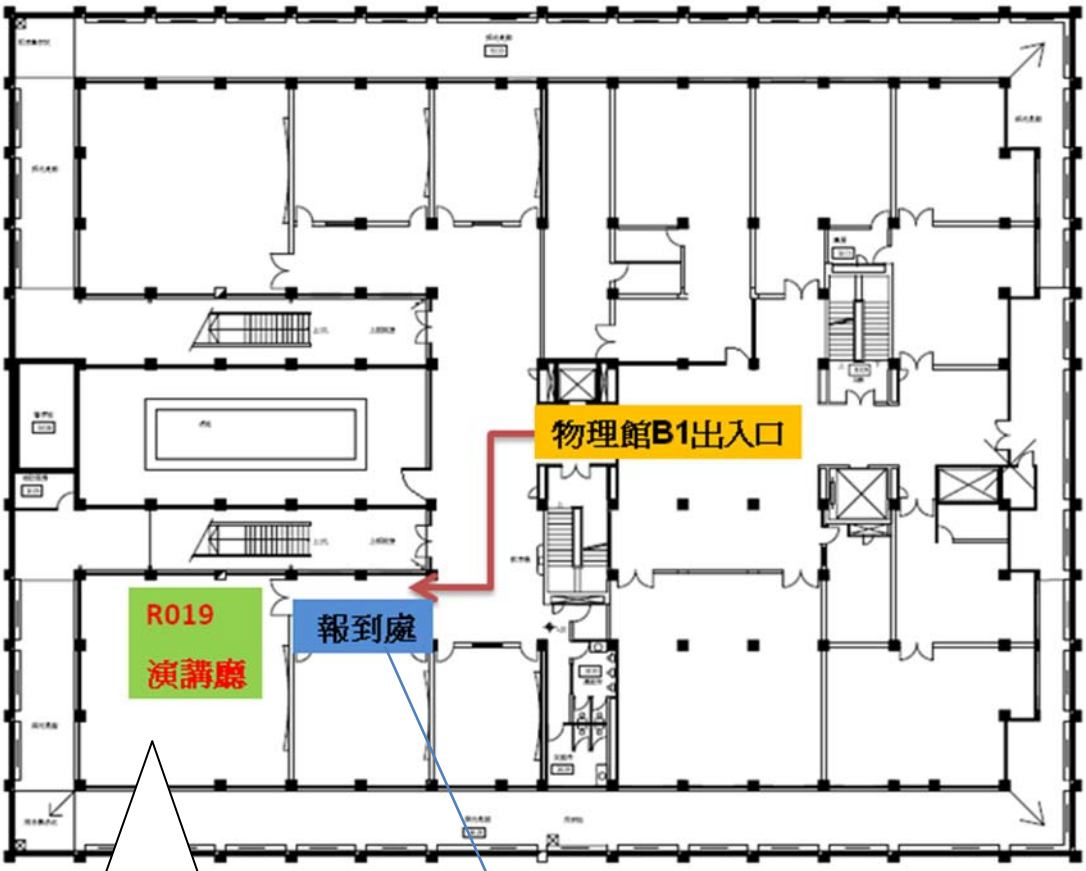
物理系張存續教授

張存續教授團隊研究磁旋返波振盪器之物理作用機制，如非線性場收縮特性、非穩態與渾沌行為、線性與時變特性、與軸向模式競爭等。成果曾發表多篇於頂級物理期刊，Phys. Rev. Lett.

會議相關資訊
Information on 2011 THz Workshop

大會地點

國立清華大學物理學系
新竹市光復路二段 101 號
http://www.phys.nthu.edu.tw/index_ch.html



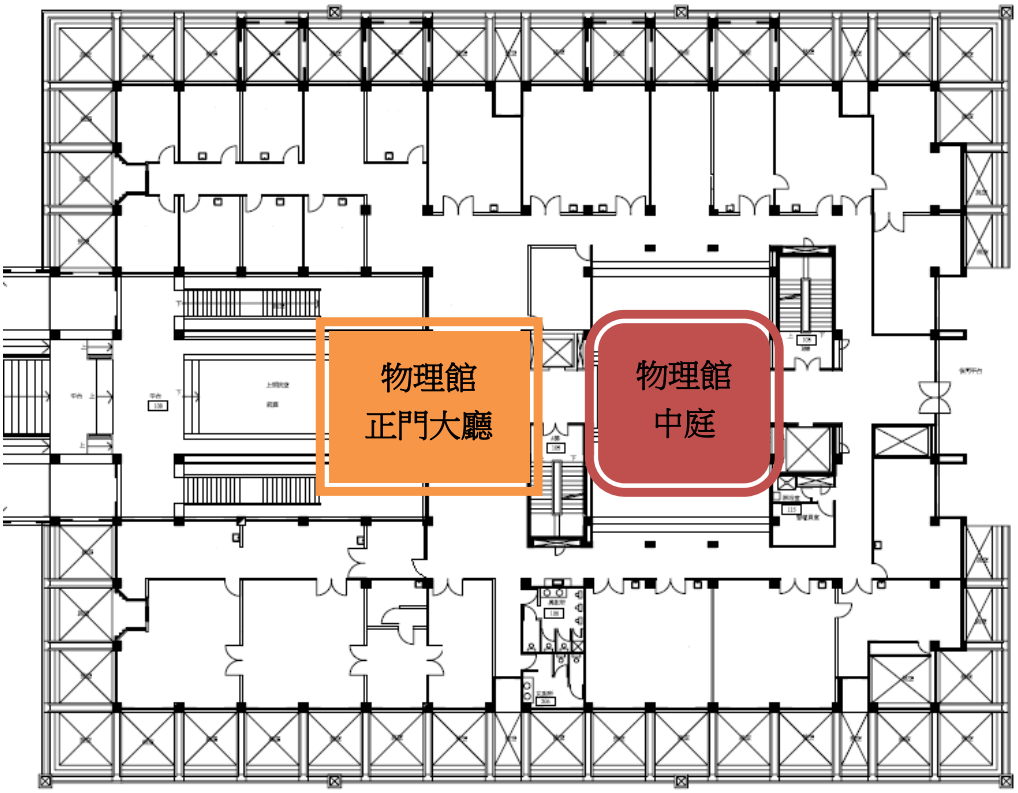
大會場地位置圖
物理館 R019 演講廳

大會報到處
大會服務台
停車卷兌換處
行李暫放區
論文海報展示區
無線網路設定說明

茶會

時間：10：20-10：40 、15：30-16：00

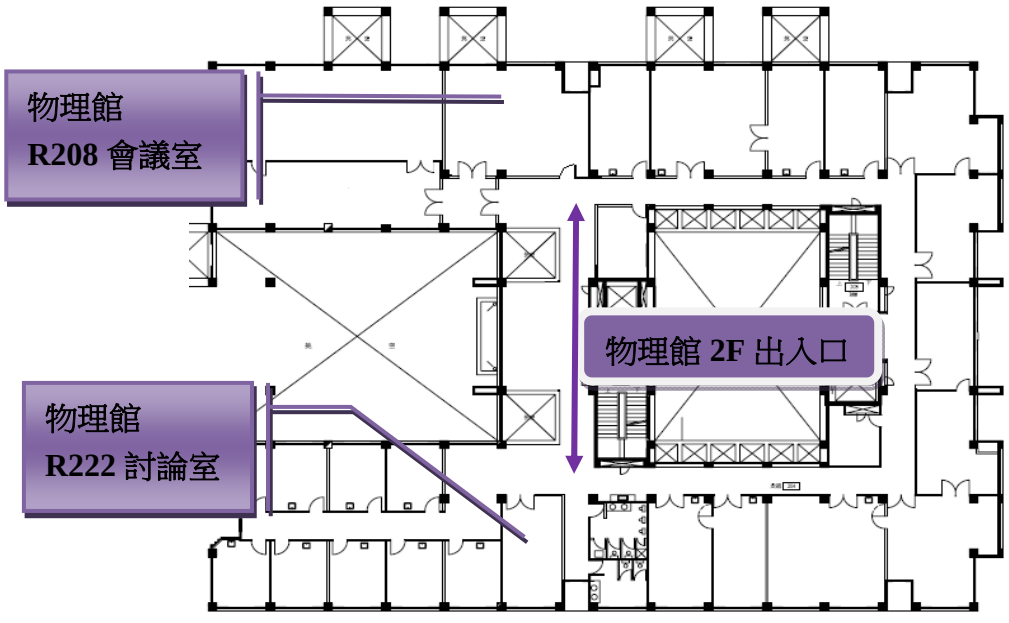
地點：物理館 1 樓中庭



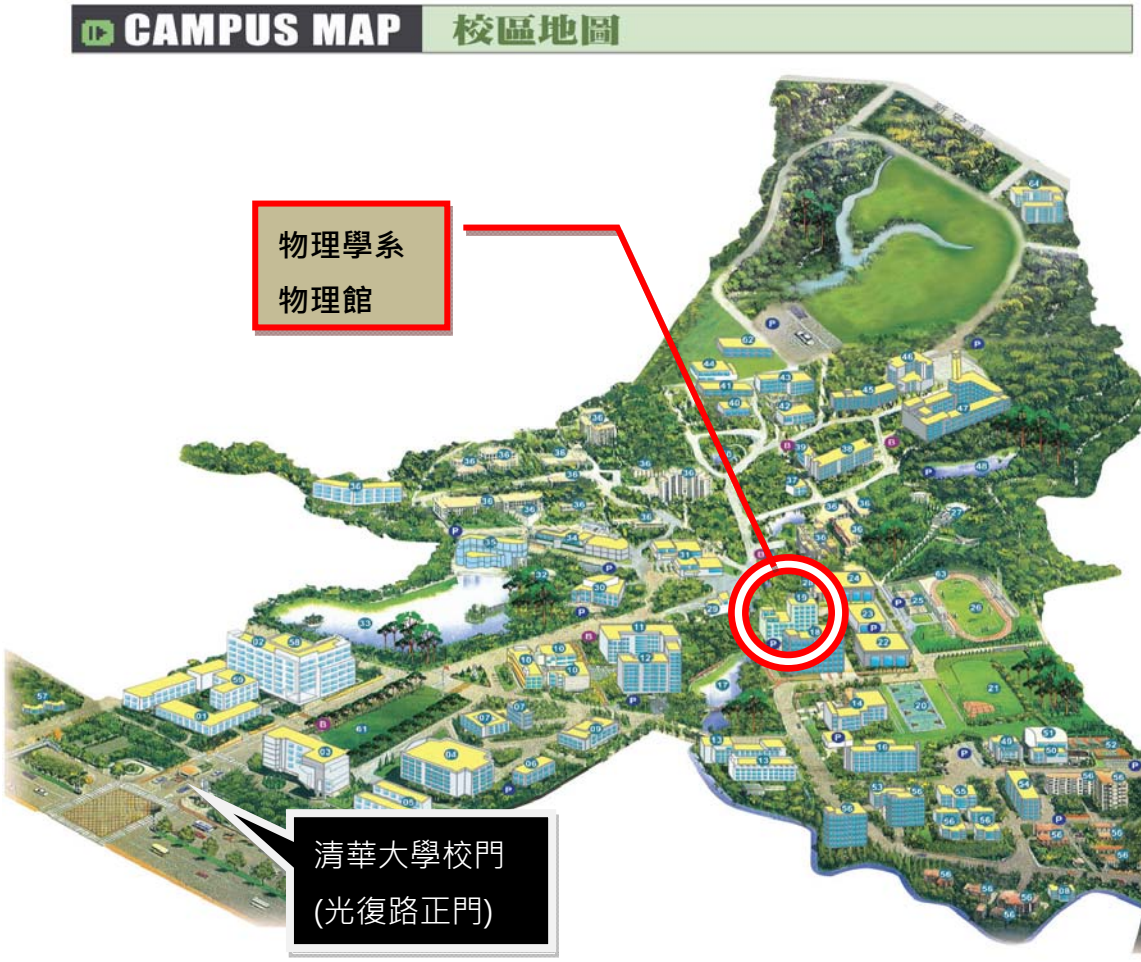
午餐

時間：12：00-13：50

地點：物理館 2 樓 R208、R222 會議室



清華大學校園地圖



01. 研發大樓
02. 工程一館
03. 化學館
04. 化工館
05. 動機化學實驗館
06. 醫輔中心
07. 材料中心 (A.B)
08. 清華會館
09. 教育館
10. 第一綜合大樓（行政大樓）
11. 第二綜合大樓
12. 第三綜合大樓
13. 工程三館
14. 資訊材料館
15. 立體機車停車場
16. 材料科技館（工程四館）
17. 昆明湖
18. 資訊電機館
19. 物理館
20. 籃球場
21. 棒球場
22. 游泳池
23. 羽球館
24. 體育館
25. 排球場
26. 田徑場
27. 梅園
28. 蒙民偉樓（學生活動中心）
29. 百齡堂
30. 大禮堂
31. 小吃部
32. 溜冰場
33. 成功湖
34. 水木生活中心
35. 風雲樓（書局、餐廳）
36. 學生宿舍
37. 駐警隊
38. 工科館
39. 原科中心
40. 原子爐
41. 同位素館
42. 生物科技館
43. 生醫工程及環境科學館
44. 加速器館
45. 生命科學一館
46. 生命科學二館
47. 人文社會館
48. 相思湖
49. 材料實驗館
50. 合金實驗館
51. 室內網球場
52. 室外網球場
53. 自強樓
54. 莊敬樓
55. 第二招待所
56. 西院宿舍
57. 東院宿舍
58. 科儀中心
59. 創新育成中心
60. 荷塘
61. 大草坪
62. 相對論光電子實驗室
63. 守德紀念岩場
64. 台積館
P. 停車場
B. 公車站

會場交通資訊 Travel to NTHU

- **自行開車**

國道路線：

※中山高二側引道與光復路、公道五路並未直接連結南下欲由光復路下交流道者，請先由公道五出口接引道。

※**自行開車之來賓請憑停車卷至大會服務台領取免費停車證。**

由中南部北上車輛	路線一	由 **95B 竹科交流道**下，左轉接園區二路，行至新安路時左轉直行，由本校南門進校園。(本路線適合考場位於人社院、工科館、生科二館、原科院考生)
	路線二	由 **95A 新竹交流道**下，左轉接光復路後直行，由本校光復路大門進校園。(本路線適合考場位於工一館、化工館、教育館、電資院、綜三館、工四館考生)
由北部南下車輛	路線一	由 **95A 公道五匣道**下交流道，選擇右方往公道五路出口，沿公道五路直行至建中路口(鄰近中油油庫)左轉，沿建中路直行至底(光復中學)再左轉光復路，可將汽車停放於「赤土崎停車場」，再步行至本校，或由本校光復路大門進入校園。
	路線二	由 **95A 公道五匣道**出高速公路後直行，經由引道接光復路後右轉直行，由本校光復路正門進入校園。 如果您錯過了上述交流道，請由下一個出口(**95B 竹科交流道**)下高速公路，右轉接園區新安路後直行，由本校南門進入校園。

- **台灣高鐵**

1.請於高鐵新竹站下車，下車後可轉搭其他交通工具，轉乘資訊請見台灣高鐵網站。

2.台灣高鐵公司自 97/1/25 起提供高鐵新竹站快捷專車免費接駁服務，沿途停靠新瓦屋(客家園區)=>交通大學=>清華大學(文教新村 ，於清大光復路大門附近)=>馬偕醫院=>二分局(東光路口)=>文化中心=>東門市場，每班車間隔約 20 分鐘一班 。

詳細班車時刻及路線圖

高鐵新竹站發車 THSR Hsinchu Station				東門市場發車 Dongmen Market			
07:15	11:50	16:50	21:15	06:05	10:40	15:40	20:15
07:50	12:15	17:15	21:50	06:35	11:15	15:55	20:50
08:15	12:50	17:35	22:15	06:55	11:40	16:15	21:15
08:35	13:15	17:50	22:50	07:10	11:55	16:40	21:40
08:50	13:35	18:15	23:15	07:35	12:15	17:15	22:15
09:15	13:50	18:35	23:50	07:55	12:40	17:30	22:45
09:35	14:15	18:50		08:15	12:55	17:50	
09:50	14:35	19:15		08:40	13:15	18:15	
10:15	14:50	19:35		08:55	13:40	18:30	
10:35	15:15	19:50		09:15	14:15	18:50	
10:50	15:50	20:15		09:40	14:40	19:15	
11:15	16:15	20:35		09:55	14:55	19:30	
11:35	16:35	20:50		10:15	15:15	19:50	

- **火車：**西部幹線 新竹站下車，下車後需轉搭其他交通工具。
- **新竹市公車：**新竹客運公車號碼：

  1 路（約每 10-15 分鐘一班）

  2 路（約 1 小時一班）

  搭乘地點：民族路，SOGO 百貨旁邊

  下車地點：清華大學站

- **計程車：**火車站→清華大學門口，車資約 150~200 元

  （若未跳錶，上車前請先與司機議價）

新竹市景點介紹 Famous tourist spots in Hsinchu

資料來源：新竹旅遊網

美食資訊 Eating at Hsinchu

地區 /景點	所在位置	美食小吃
城隍廟夜市	新竹市北區中山里中山路 75 號	汕頭火鍋、摃丸、米粉、肉圓、魷魚羹、肉粽、裸粽、潤餅捲、魚丸、蚵仔煎
花園街夜市	新竹市花園街(東大路橋下)	各式台灣小吃、新加坡美食餐廳
清大夜市	清華大學校門口對面之建功路	小洞天糯米腸、風格傳統豆花、脆皮雞排
新復珍竹塹餅	新竹市北門街六號 (城隍廟邊)	竹塹餅、綠豆椪、麻糬
黑貓肉包	新竹市北門皆 187 號	黑貓肉包
光復饅頭店	新竹市光復路二段 92 號	各式包子饅頭

緊急聯絡電話 Important Numbers

Office of Department of Physics, NTHU	(03) 574-2306 (03) 516-2576
Fire & Emergency /火警、緊急事故	119
Police & Traffic Accident /警察報案、交通事故	110
Local Call Directory /市區電話查詢	104
Long Distance Call Directory /長途電話查詢	105
International Information Directory /國際電話查詢或掛發	100
Taiwan Taoyuan International Airport / 臺灣桃園國際機場 The Service Counter of the Departure Hall for 24- hour /Terminal 1 The Service Counter of the Departure Hall for 24- hour /Terminal 2 Website: http://www.taoyuan-airport.com/chinese/index.jsp	(03)398-2143 (03)398-3274
Taiwan High Speed Rail / 台灣高鐵 Website: http://www.tTHSR c.com.tw/en/?lc=en	4066-3000
Kuo-Kuang motor transport / 國光客運 Website: http://www.kingbus.com.tw/index.php	0800-010-138
HsinChu Transportation Co., Ltd. / 新竹客運 Website: http://www.hcbus.com.tw/	(03)522-5151
Inquiry for International Telecommunication Service (free) / 查詢國際電信業務電話（免費）	0800-731-123
Department of Tourism Hsinchu City Government / 新竹市政府觀光處 Website: http://dep-tourism.hccg.gov.tw/	(03)521-6121

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