[Young reseachers' poster presentations]

7. Optical Nanofibers for Manipulating Atoms and Photons

Kali Prasanna Nayak (Hakuta Group, Department of Applied Physics and Chemistry, University of Electro-Communications)

We present the development of a novel method for manipulating atoms and photons using a subwavelength diameter silica fiber, an optical nanofiber. Such a technique enables us to observe very small number of atoms around the nanofiber by detecting the fluorescence photons through the single guided mode of the nanofiber. Using laser-cooled Cs-atoms we experimentally demonstrate efficient coupling of atomic fluorescence into the guided mode of an optical nanofiber. Using photon correlation experiments we demonstrate that single atoms can be detected using an optical nanofiber. A key point is the single spatial mode nature of the nanofiber guided mode. We show that due to the single mode observation of few-atom fluorescence the photon correlations evolve as interplay between both the first- and second-order coherences with increasing atom number. Moreover due to the inherent nature of the nanofiber method the atom-surface interactions become a crucial issue in such a system and are systematically investigated.

8. Development of a Pre-Stabilized Laser for Next-Generation Ground-Based Gravitational-Wave Detectors

Noriaki Ohmae (Mio Group, Department of Advanced Materials Science, University of Tokyo)

Kilometer-scale interferometers for gravitational-wave detection are being developed all over the world. In order to enhance their sensitivity to gravitational waves, laser sources having high output power and extremely low noises are needed. So far, we developed a 100-W injection-locked Nd:YAG laser for Japanese next-generation detector, called large-scale cryogenic gravitational-wave telescope (LCGT). Currently, we are developing a pre-stabilization system for this laser. First, we tried to stabilize the frequency noise of this laser relative to a reference cavity. As a fast frequency actuator for high-power lasers, we developed special electro-optic modulators made of stoichiometric lithium niobate crystals. Using this modulator and the piezoelectric transducers on the laser crystal, we have realized the control system of wideband (Unity gain frequency: 100 kHz) and high gain (170 dB at 1 kHz); these parameters satisfy the requirement of frequency-stabilization system in LCGT. In my presentation, I will talk about the current status of laser development for LCGT and the frequency-stabilization experiment.

9. The Quest for Bose-Einstein Condensation of Excitons

Kosuke Yoshioka (Gonokami Group, Department of Applied Physics, University of Tokyo)

It has been a long-term dream in solid-state physics to experimentally realize a Bose-Einstein condensate (BEC) of excitons and to look at its fascinating properties. This is the issue of a gas of elementary excitations being able to turn into the truly quantum statistical phase in the first place, and the realization can even help us deeply understand high-Tc superconductors. Despite quite a large amount of effort for many years, there has been no decisive evidence of the condensation ever reported. Here we would like to show why it is difficult and how we are going to cross the barrier, in one of the promising host materials for excitonic BEC: cuprous oxide. The presentation will include: observation of large inelastic collision cross sections of dark excitons even at low temperatures, trapping and accumulating excitons in a semiconductor crystal, and recent progress towards the observation of excitonic BEC at sub-Kelvin temperatures.

10. Three dimensional optical lattice clocks with bosonic ^{88}Sr atoms

Tomoya Akatsuka (Katori Group, Photon Science Center, University of Tokyo)

Optical lattice clocks [1] interrogate millions of atoms trapped in the Lamb-Dicke regime of optical lattices, which suppresses the Doppler shift and improves the quantum projection noise limited stability of singly trapped ion based clocks. The use of many atoms, in turn, may introduce collisional frequency shift, which is a major challenge for the lattice clock. For fermionic atoms, collision suppression by Pauli blocking has been explored by using spin-polarized ^{87}Sr atoms in a 1D optical lattice [2]. Alternatively, atoms may be trapped in a single occupancy 3D lattice, which is applicable to bosonic atoms.
We constructed a 3D lattice clock based on bosonic ^{88}Sr atoms [3] in addition to a 1D lattice clock with spin-polarized fermionic ^{87}Sr. Sequential operation of the two clocks allowed to evaluate the stability as well as the uncertainty of the clocks. The Allan deviation calculated from the beat note of the two clocks reached 5×10^{-16} for an averaging time of 2000 s. The isotope shift of the clock transitions was determined to be 62,188,138.4 Hz with the uncertainty of 1.3 Hz.

[1] H. Katori et al., Phys. Rev. Lett. 91, 173005 (2003).
[2] M. Takamoto et al., J. Phys. Soc. Jpn. 75, 104302 (2006).
[3] T. Akatsuka et al., Nat. Phys. 4, 954 (2008).

11. Photo-induced precession of magentization in a III-V-based ferromagnetic semiconductor

Satoi Kobayashi (Munekata Group, Department of Electronics and Applied Physics, Tokyo Institute of Technology)

In 2005, we found that optical excitation of ferromagnetic (Ga,Mn)As with laser pulses could give rise to the precession of ferromagnetically coupled Mn spins. Svereal groups have also confirmed the photo-induced precession since then. Last year, we have reported, through the study of photo-induced precession in $Ga_{0.98}Mn_{0.02}As$ that non-thermal influence of optical excitation is responsible for this phenomenon, at least in weak excitation regime; a torque that works on coupled Mn spins is produced by the slight canting of a p-d-exchange-induced magnetic anisotropy field during photo-generation, cooling, and subsequent annihilation of extra holes of the order of 10^{16} to 10^{17} cm^{-3}. I am going to present how we are able to arbitrary control the spin dynamics, which is one of the most advanced experimental results in our group.

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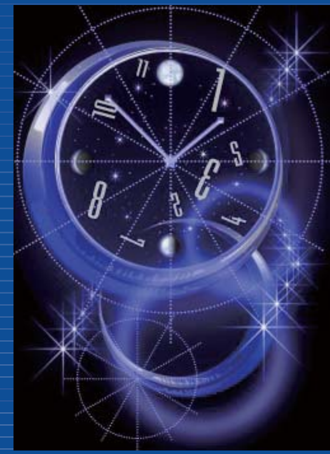


John L. Hall 先生
若手研究者との集い

Forum for Dr. John L. Hall and young research careers

日 時：平成 21 年 3 月 25 日（水） 午前 10 時から午後 5 時
場 所：東京大学 本郷キャンパス 理学部 1 号館、小柴ホール

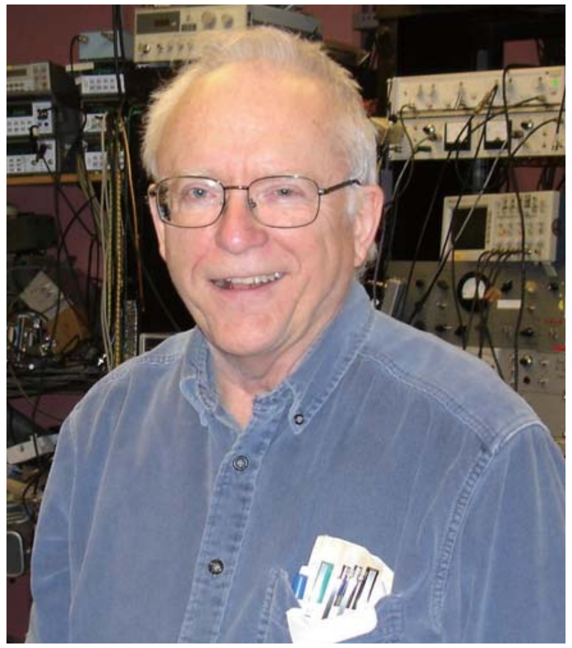
主催：東京大学 大学院工学系研究科 総合研究機構、後援：東京大学 大学院工学系研究科

プログラム

10:00–10:05	開式の辞：保立 和夫（工学系研究科） Opening Message: Kazuo Hotate (School of Engineering)
10:05–10:45	"Optical lattice clocks and optical networks: a new probe for science" 香取 秀俊 Hidetoshi Katori（工学系研究科 School of Engineering）
10:45–11:05	"Impacts of atomic clocks on Astronomy and Geophysics" 小山 泰弘 Yasuhiro Koyama（情報通信研究機構 NICT）
11:05–12:00	若手研究者によるショートプレゼンテーション Short presentations by young researchers
12:00–13:40	昼休 Lunch
13:40–14:40	ポスターセッション【小柴ホール ホワイエ】Poster session
14:40–15:20	"Symmetry Breaking in Bose–Einstein Condensates" 上田 正仁 Masahito Ueda（理学系研究科 School of Science）
15:20–16:50	特別講義（工学部グローバルセミナー） "From Bluejeans to Formalwear – Some thoughts for guiding young research careers, based on my 45 years of fun and progress in Lasers and Optical Physics" Dr. John L. Hall (JILA, University of Colorado)
16:50–17:00	閉式の辞：五神 真（工学系研究科，光量子科学研究センター） Closing Remarks: Makoto Gonokami (School of Engineering, UT–PSC)

●特別講義は東京大学工学部グローバルセミナーとして実施いたします。
●講演はすべて英語です。

UT-PSC Photon Science Center of the University of Tokyo
APSA Advanced Photon Science Alliance
東京大学 THE UNIVERSITY OF TOKYO
NICT
大学院工学系研究科
グローバル COE 未来を拓く物理科学結集教育研究拠点



Dr. John L. Hall is the foster father of lasers. He just missed the birth of the lasers because he was a bit too young. Other than that, he has continuously loved and taken care of lasers for nearly fifty years so that 100% of its talent is revealed. He has made enormous contributions in laser technologies, including various techniques to stabilize CW and pulse lasers, spectroscopic detection of molecular photon recoils, molecular optical clocks, frequency combs, and so on. All of these efforts have resulted in more precise measurements of the time and frequency, which formed the base of the current science and technology. You may have learned that the speed of light is exactly 2.99792458 (no "…" here!) $\times 10^8$ m/s and simultaneously defines the unit of length, meter. Jan is the scientist who contributed to determine this number in early 1970's with several colleagues in NBS (National Bureau of Standards, former name of NIST). Nobody is eligible to measure it since then. Another insight we should note is his influence to the whole community of laser physics. His carrier as a NBS/NIST physicist synchronizes with an impressive success of a research institute JILA. Lots of active scientists in this field have experience to work for him in JILA as either students, postdocs, or visiting scientists. They know that his life has been firmly supported by his wife, Lindy's great help, and that his productivity was boosted by a healthy competition and a warm friendship between Jan and Nobel co-laureate T. Haensch.

[Guest presentations]

Optical lattice clocks and optical networks: a new probe for science

Hidetoshi Katori (Department of Applied Physics, University of Tokyo)

The precision measurement of time and frequency provides an essential basis for fundamental science as well as for technologies that support broadband communication networks and the navigation with global positioning systems. Thanks to the optical frequency comb technique, which established a coherent link between optical and radio frequencies, optical clocks have attracted increasing interest as regards future atomic clocks with higher stability. Nearly for a decade we explored a novel approach for optical atomic clocks, namely an "optical lattice clock," in which millions of atoms trapped in a carefully designed optical lattice serve as quantum references free from the Doppler shift and light field perturbations. The use of many atoms not only improves the quantum projection noise limited clock stability but also allows studying quantum many body systems with hitherto unexplored precision. Potential applications for high precision atomic clocks projecting at 10^{-18} uncertainty will be discussed.

Impacts of atomic clocks on Astronomy and Geophysics

Yasuhiro Koyama (National Institute of Information and Communications Technology)

Invention of atomic clocks made a variety of impacts on science and technology. Many people may not be aware but the presence of atomic clocks is now essential for every day life. Very Long Baseline Interferometry (VLBI) is one of the typical examples which are enabled by the invention of atomic clocks. In 1960s, scientists succeeded to combine radio signals received at two or more radio telescopes apart with great distances. It became possible because the recorded radio signals can be recorded with precise timing. As the results, radio interferometer with virtual aperture up to the size of the earth was realized. By using this technique, astronomers are observing far away Quasers and other celestial objects with unprecedented angular resolution, and geophysicists are observing the dynamics of the earth. Thus the VLBI has become powerful tool in today's Astronomy and Geophysics.

Symmetry Breaking in Bose-Einstein Condensates

Masahito Ueda (Department of Physics, University of Tokyo)

The Nobel prize of physics in 2009 was awarded to Nambu, Kobayashi, and Maskawa who made pioneering work on symmetry breaking at the level of nuclear and elementary particle physics. Although symmetry breaking is ubiquitous in Nature, it emerges in a subtle manner in Bose-Einstein condensation in the form of off-diagonal long-range order. In this talk, I will argue that ultracold atoms offer a cornucorpia of symmetry breaking and thus offer an ideal testing ground for the study of this subject. I will substantiate this idea by taking examples from scalar, spinor, and dipolar Bose-Einstein condensates.

[Young reseachers' poster presentations]

1. Quantum teleportation of Schrödinger's cat states

Tadashi Takeno (Furuswa Group, Department of Applied Physics, University of Tokyo)

We realized quantum teleportation of Schrödinger's cat states in wavepacket modes. In the presentation, we will show the detail of the experimental technique. A Schrödinger's cat state has a big negative dip in its Wigner function, and is generated by subtracting a photon from a squeezed vacuum state utilizing a single-photon detector. Therefore the generated cat state is excited in a wavepacket mode located around the photon-detected time. To teleport this broadband wavepacket mode, we, at first, improved our teleportation system because a very narrow sideband mode had been teleported in the former teleportation experiments. Then we prepared a cat state as an input of quantum teleportation. We observed non-Gaussian characteristic at the output. This is the first realization of quantum operation for non-Gaussian states in continuous variable experiments.

2. Spectroscopic study towards the production of ultracold absolute ground state $^{41}K^{87}Rb$ molecules

Kiyotaka Aikawa (Inoue Group, Department of Applied Physics, University of Tokyo)

Quantum degenerate gases of polar molecules are regarded as one of the most exotic quantum many-body systems for the anisotropic and long-range nature of the dipole-dipole interaction. We plan to produce them by associating ultracold atoms to form ultracold diatomic polar molecules. Here the process involves two steps: the first is to form weakly bound molecules from quantum degenerate atomic gases with the aid of a Feshbach resonance and the second is to transfer them into the lowest rovibrational level of the molecular ground state by Stimulated Raman Adiabatic Passage (STIRAP) for stabilizing molecules against collisions with each other. To achieve a high transfer efficiency in the STIRAP process, we need an intermediate state which couples strongly with both the weakly bound level and the lowest rovibrational level. In this poster, we report our spectroscopic study to identify the optimum intermediate state in the STIRAP process for $^{41}K^{87}Rb$ molecules.

3. Formation of s-Wave and p-Wave Pairs in a Ultracold Fermi Gas

Yasuhisa Inada (Gonokami Group, Department of Applied Physics, University of Tokyo)

The pairing of fermions is an essential ingredient of superconductivity of electrons and of the superfluidity of ^3He. While such phenomena are accurately described by BCS theory in the limit of weak interaction between particles, a complete understanding remains elusive when interaction is strong, such as in high-Tc superconductors. We created ultracold gases of fermionic ^6Li atoms and studied s-wave and p-wave pairing. Feshbach resonances enable the continuous and dynamical tuning of both strength and sign of interaction between the atoms. The control of s-wave interaction allows to access the crossover between Bose-Einstein condensation (BEC) of molecules and BCS superfluidity of Cooper pairs. We measured the critical temperature throughout the BCS-BEC crossover. We also created p-wave molecules by utilizing the p-wave Feshbach resonance. P-wave superfluids of fermionic atoms would offer great opportunities to study various superfluid phases with the fine tunability of interaction. We measured the scattering properties of p-wave molecules and discuss the feasibility of p-wave superfluidity.

4. Loss features in the three-component mixture of ^6Li atoms

Shuta Nakajima (Ueda Group, Department of Physics, University of Tokyo)

Since the first report of the three-body loss feature in the three component mixture of ^6Li[1], there has been an increasing interest to the loss mechanism in the context of the trimer formation. We made a balanced mixture of three lowest-lying hyperfine states of ^6Li atoms by means of rf magnetic field and confirmed that the three-component mixture showed a large loss at 130 G. In order to identify the detailed physical process of the loss features, we study how the three-body loss is affected by experimental conditions such as the magnetic field sweep rate and direction. From the experiments we found that the loss features at 130 G was not affected by direction of the magnetic sweep. Now, we are interested in confirming the existence of the trimer state and measuring its binding energy.

[1] T. B. Ottenstein et.al., PRL 101, 203202 (2008).

5. Ultra-Short-Pulse Generation from Diode-Pumped Yb^{3+}-Doped Ceramic Laser with High Average

Masaki Tokurakwa (Ueda Group, Institute of Laser Science, University of Electro-Communications)

Yb^{3+}-ion-doped ceramic materials are one of the most promising candidates for compact high power femtosecond lasers. Their emission and absorption properties enable femtosecond laser operation with direct laser diode pumping. The unique quasi-three-level energy scheme of Yb^{3+} ions also leads to a small quantum defect and absences of undesirable effects such as excited-state absorption and cross relaxation. In addition the ceramic materials have size scalability and higher thermal shock parameters than those of single crystals. In combination with properties of Yb^{3+}-ion and ceramic, Yb^{3+}-ion-doped ceramic materials allow very high intensity and high power pumping so that highly efficient high average power femtosecond laser operation can be obtained. On the other hand, the deficiency of Yb^{3+}-ion-doped materials is limited pulse duration by their gain bandwidths. To overcome the limitation, we have investigated a Kerr-lens mode-locked multi-gain media oscillator. As a result, pulses as short as 53 fs with above 1-W average power has been obtained.

6. Enhanced solubility limit of Eu^{3+} in $LaVO_4$ films grown by pulsed laser deposition

Takuya Higuchi (Hwang Group, Department of Advanced Materials Science, University of Tokyo)

Eu^{3+} doped rare-earth orthovanadates are known to be good red phosphor materials. Especially, $LaVO_4:Eu^{3+}$ is a promising candidate due to the poor point symmetry around the Eu^{3+} site, and thus the expected high probability of dipole transitions according to Judd-Ofelt theory. However, the poor solid solubility limit (<3 mol%) of Eu^{3+} in $LaVO_4:Eu^{3+}$ prevented its efficiency as a phosphor. In this presentation, we show optical evidence of the enhanced Eu^{3+} solubility as high as 10 mol% in $LaVO_4:Eu^{3+}$ thin films grown by pulsed laser deposition (PLD). The photoluminescent intensity exceeds that of $YVO_4:Eu^{3+}$ thin films, which is used as a commercial phosphor, when excited by light with lower energy than the host bandgap, indicating the stronger direct emission of Eu^{3+} in $LaVO_4$. The non-equilibrium growth process in PLD has been thought to be an obstacle to fabricate high quality thin films. From an opposite viewpoint, this fact can be utilized to stabilize a material which cannot exist in bulk.