The 7th Workshop on Physics

between

Ecole Normale Superieure and University of Tokyo

Département de Physique
École Normale Supérieure

東京大学
THE UNIVERSITY OF TOKYO

November 25-26, 2019

Hongo Campus, University of Tokyo

ENS-UT Workshop on Physics

November 25-26, 2019

Hongo Campus, University of Tokyo

Faculty of Science, Building No.4, Room 1320 (3rd floor)

Workshop Program

November 25, 2019

9:30-	*Welcome coffee*
9:50-10:00	Welcome address
10:00-10:30	Jakob Reichel “Spin Squeezing at a Metrologically Relevant Level”
10:30-11:00	Hidetoshi Katori “Transportable Optical Lattice Clocks to Test Gravitational Redshift”
11:00-11:30	Sébastien Gleyzes “Cat States and Quantum Metrology with Rydberg Atoms”
11:30-12:00	Masahito Ueda “Discrete Time-crystalline Order in Cavity and Circuit QED Systems”
12:00-13:30	*Lunch*
13:30-14:00	Kazuhiko Hirakawa “Terahertz Spectroscopy of Electron - vibron Coupling in Single Molecules”
14:00-14:30	Robson Ferreira “Graphene Quantum Dots in the THz domain”
14:30-15:00	Ryo Shimano “Electron-hole Bardeen-Cooper-Schrieffer State in a Photoexcited Semiconductor”
15:00-15:30	Synge Todo “Data Assimilation in Materials Science - crystal Structure Prediction Supported by Incomplete Experimental Data”
15:30-16:00	*Break*
16:00-16:30	Matthieu Delbecq “Sensing a Synthetic Spin Texture with Cavity Photons”

16:30-17:00 Kensuke Kobayashi
"Non-equilibrium Fluctuations in Correlated Quantum Liquids"
17:00-17:30 Gwendal Fève
"Microwave Photons Emitted by Fractionally Charged Quasiparticles"
17:30-18:00 Seigo Tarucha
"Quantum Non-demolition Measurement of Single Spins"

November 26, 2019

10:00-10:30 Satoshi Yamamoto
"Why Chemistry in Astronomy?"
10:30-11:00 Edith Falgarone
"A Tale of Turbulence and Gravity"
11:00-11:30 Naoki Yoshida
"Cosmological Simulations of Galaxy Formation"

11:30-13:00 *Lunch*

13:00-13:30 Yasushi Okada
"Dissecting the Molecular Mechanisms of Axonal Transport Through Single Molecule and Super-resolution Imaging"
13:30-14:00 Frederic Pincet
"In Vitro Recapitulation of Synaptic Transmission with Model Physiological Membranes"
14:00-14:30 Tetsuya Kobayashi
"Understanding Biological Sensing and Its Optimality"
14:30-15:00 Jean François Allemand
"Some Single DNA Micromanipulation Experiments"
15:00-15:30 Takahiro Sagawa
"Thermodynamics of Information"

15:30-15:45 Closing

Long-lived spin squeezing and quantum phase magnification

Meng-Zi Huang[1], Tommaso Mazzoni[2], Konstantin Ott[1], Carlos Garrido-Alzar[2] & Jakob Reichel[1]
[1]*Laboratoire Kastler Brossel, Ecole Normale Supérieure – Université PSL, CNRS, Sorbonne Université, Collège de France, 24 rue Lhomond, 75005 Paris, France*
LNE-SYRTE, Observatoire de Paris – Université PSL, CNRS, Sorbonne Université, 61 Avenue de l'Observatoire, 75014 Paris, France
jakob.reichel@ens.fr

The spectacular progress of atomic clocks has turned them into the most precise of all physical instruments available today. Beyond metrology, this precision also opens a new window on many-body physics in ultracold atomic ensembles, much of which occurs on energy scales that only these instruments can resolve. These clocks, and indeed all sensors utilizing uncorrelated particles are ultimately limited by quantum projection noise, as is already the case for some state-of-the-art instruments today. This so-called standard quantum limit (SQL) can be overcome by preparing the particles in a many-body entangled state, such as a spin-squeezed state. Atomic spin-squeezing has been generated in spectacular proof-of-principle experiments. In these experiments, however, the entanglement was rather short-lived (typical coherence times on the order of milliseconds), precluding clock measurements in any metrologically relevant regime. In a collaboration with the French time and frequency laboratory SYRTE (Observatoire de Paris), we have now produced spin-squeezed states with coherence times on the order of a second in the experimental platform of a trapped-atom clock on a chip. Besides the metrological perspective of enabling quantum-enhanced clock measurement in the range of 10^-13 s^-1/2 (the regime of next-generation compact atomic clocks), these long coherence times reveal a surprising quantum phase magnification effect resulting from a subtle interplay of spin dynamics and non-demolition measurement of the collective spin.

Transportable Optical Lattice Clocks to Test Gravitational Redshift

Hidetoshi Katori
Department of Applied Physics, The University of Tokyo, Tokyo 113-8656, Japan
Quantum Metrology Laboratory, RIKEN, Wako, Saitama 351-0198, Japan
katori@amo.t.u-tokyo.ac.jp

An "optical lattice clock" proposed in 2001 [1] benefits from a low quantum-projection noise by simultaneously interrogating a large number of atoms trapped in optical lattices tuned to the "magic frequency" [2] that largely cancels the light shift perturbation of the lattice trap. About a thousand atoms enable such clocks to achieve 10^{-18} instability in a few hours of operation, which allows intensive investigation of systematic uncertainties and finding new applications.

We report recent topics including 1) an "operational magic condition" [3, 4] to reduce the clock uncertainty to 10^{-19} by cancelling out the higher-order light shifts than that given by the electric-dipole interaction, 2) transportable Sr-based clocks with an uncertainty of 10^{-18} that were being operated outside a laboratory, and 3) testing of the gravitational redshift using 450-m-high tower.

References

[1] H. Katori, in *Proc. of the 6th Symp. on Frequency Standards and Metrology*, edited by P. Gill (World Scientific, 2001), pp. 323.

[2] H. Katori, M. Takamoto, V. G. Pal'chikov, and V. D. Ovsiannikov, Ultrastable optical clock with neutral atoms in an engineered light shift trap, Phys. Rev. Lett. **91**, 173005 (2003).

[3] H. Katori, V. D. Ovsiannikov, S. I. Marmo, and V. G. Palchikov, Strategies for reducing the light shift in atomic clocks, Phys. Rev. A **91**, 052503 (2015).

[4] I. Ushijima, M. Takamoto, and H. Katori, Operational Magic Intensity for Sr Optical Lattice Clocks, Phys. Rev. Lett. **121**, 263202 (2018).

Quantum Metrology with Rydberg Atoms

Sébastien Gleyzes
Laboratoire Kastler Brossel, Collège de France, CNRS, ENS-PSL Research University, UPMC-Sorbonne Universités, 11 place Marcelin Berthelot, 75005, Paris, France
gleyzes@lkb.ens.fr

Rydberg states correspond to electron wave function localized at a very large distance from the nucleus. These giant atoms are extremely sensitive to their electromagnetic field environment. It is possible to prepare state with very large electric dipole to probe the amplitude of the electric field, or states with very large angular momentum, able to detect very small magnetic field. As often in quantum metrology experiment, the limit of the sensitivity is set by the quantum fluctuations associated with the state of the atom. To reach the ultimate sensitivity set by the law of quantum mechanics, called the Heisenberg limit, it is necessary to prepare the atom in a non-classical states, like a Schrödinger cat state.

Our system is a Rydberg atom with a large quantum principal number $n \sim 50$. In the presence of a small electric field defining the quantization axis, the degeneracy between levels with the same n is lifted. The new eigenstates, called Stark levels, are defined by the magnetic quantum number m, which remains a good quantum number, and the parabolic quantum number n_1, with $0 \leq n_1 \leq n-|m|-1$. Since m remains a good quantum number, it is possible, using a radio frequency field with a well-defined $\sigma+$ polarization, to restrict the evolution of the atom to a subspace of the Stark manifold where the system behaves like a large spin $J = (n - 1)/2$, whose frequency is proportional to the local amplitude of the electric field. We have used this effective spin to perform a quantum-enabled measurement of the static electric field. We prepare a Schrödinger cat state of the Rydberg atom, quantum superposition of two classically distinct wavefunction with very different electric dipole, and observe how the relative phase between the two components of the quantum superposition provides a very sensitive signal to measure the variation of the static electric field [1]. We achieve a precision that exceeds the SQL and approaches the fundamental Heisenberg limit (HL). The single-shot sensitivity reaches 0.3 mV/cm for a 200 ns interaction time, (8 μV/cm/ √Hz at a 3 kHz repetition rate). This highly sensitive, non-invasive space- and time-resolved field measurement extends the realm of electrometric techniques and could have important applications.

Driving the Rydberg atom with a combination of $\sigma+$ and $\sigma-$ polarization also open the way to explore the full set of Stark level, and in particular prepare quantum superposition of state with same parabolic number but opposite value of m. Such states are very interesting for magnetic metrology, as they correspond to microscopic probe with up to 100 μB magnetic moment, while at the same time being impervious to electric field noise [2].

References

[1] A. Facon, *et al*, Nature **535**, 262–265 (2016)
[2] E.-K. Dietsche *et al*., Nature Physics, **15**, 326–329 (2019)

Discrete Time-Crystalline Order in Cavity and Circuit QED Systems

Masahito Ueda
Department of Physics, University of Tokyo,
7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan
ueda@phys.s.u-tokyo.ac.jp

We propose an open-system setup to realize the discrete time-crystalline (DTC) order based on a modified open Dicke model, which can be implemented in cavity and circuit QED systems [1]. It is well-known that the open Dicke model, which describes a collective light-atom interaction in the presence of photon loss, exhibits a supperadiant phase transition in the strong-coupling regime. We show that a DTC order can be realized by simply switching on and off a strong light-atom interaction periodically. In the thermodynamic limit with infinite atoms, we find a rich variety of dynamical phases with different types of DTC orders, which turn out to be related to bifurcation theory. In the deep quantum regime with few atoms, we show a clear transient DTC order stabilized by photon loss. These theoretical predictions are testable in light of the state-of-the-art experiments in atomic, molecular and optical physics.

References

[1] Z. Gong, R. Hamazaki, and M. Ueda, Phys. Rev. Lett. **120**, 040404 (2018)

Terahertz Spectroscopy of Electron - vibron Coupling in Single Molecules

Kazuhiko Hirakawa and Shaoqing Du
Institute of Industrial Science and INQIE, University of Tokyo
4-6-1 Komaba, Meguro-ku, Tokyo 153-85051, Japan
hirakawa@iis.u-tokyo.ac.jp

Clarifying electronic and vibronic properties of individual molecules provides key insights to future tailor-made medicine, chemistry, nanoelectronics, and quantum information technologies. Terahertz (THz) spectroscopy has been developed as a powerful tool for clarifying vibrational dynamics of various kinds of molecules. Because of the long-wavelength nature of the THz radiation (typically, ~100 microns), however, spectral information was obtained only for ensemble average of a huge number of molecules. It has been a formidable challenge to overcome the diffraction limit and focus THz radiation on a single molecule. Furthermore, the number of mobile charges that can absorb THz radiation in a single molecule is very few, which makes THz absorption by a single molecule extremely small.

Here, we report on the THz spectroscopy of single molecules by using the single molecule transistor (SMT) geometry [1]. Using the source and drain electrodes separated by a sub-nm gap as a THz antenna [2], we focused the THz radiation onto a single fullerene molecule trapped in the nanogap electrodes and measured THz-induced photocurrent in the SMT. A great advantage of the present SMT geometry is that the electrostatic potential and the number of electrons on the molecule can be precisely controlled. We have observed low energy vibrational modes due to the center-of-mass nanomechanical motion of the fullerene molecule. Furthermore, we found that the observed peaks are finely split into two, reflecting the difference in the van der Waals potential profile experienced by the molecule on the metal surface when the number of electrons on the molecule fluctuates by one during the single electron tunneling process. Such an ultrahigh-sensitivity to the electronic/vibronic structures of a single molecule upon adding/removing a single electron has been achieved by using the THz spectroscopy in the SMT geometry. This SMT scheme provides a novel opportunity for investigating ultrafast THz dynamics of sub-nm scale systems.

References

[1] S. Q. Du, K. Yoshida, Y. Zhang, I. Hamada, and K. Hirakawa, Nature Photonics **12**, 608 (2018).
[2] K. Yoshida, K. Shibata, and K. Hirakawa, Phys. Rev. Lett., **115**, 138302 (2015).

Graphene Quantum Dots in the THz Domain

R. Ferreira
Laboratoire de Physique de l'Ecole Normale Supérieure, 24 Rue Lhomond, Paris F-75005, France
robson.ferreira@ens.fr

The energy spectrum of graphene quantum dots presents pronounced discretization effects and is highly sensitive to lateral disorder, because of its usually large perimeter to surface ratio. We have performed calculations of the electron spectrum and optical absorption of graphene quantum dots. We discuss the emergence of bulk-like features in the spectrum and its polarization-dependent optical response, for model QDs of increasing size, in the low energy (THz) domain.

Electron-hole Bardeen-Cooper-Schrieffer state in photoexcited semiconductors

Ryo Shimano[1,2]
[1]*Cryogenic Research Center, The University of Tokyo, Tokyo 113-0032, Japan*
[2]*Department of Physics, School of Science, The University of Tokyo, Tokyo 113-0033, Japan*
shimano@phys.s.u-tokyo.ac.jp

Concept of a Cooper pair plays a key role in quantum condensation phenomena in many-body systems. After the original Bardeen-Cooper-Schrieffer (BCS) theory for superconductivity, many kinds of fermionic condensates where particles other than electrons form Cooper pairs have been unveiled, e.g. in the superfluid ^{3}He, fermionic ultracold atomic gases, and theoretically in quark matters. An electron-hole (e-h) system in photoexcited semiconductors offers another fascinating arena to explore the pair condensation phenomena. In the low-density region, electrons and holes are strongly bound to form quasi-bosonic elementally excitations, called excitons, which have been expected to undergo Bose-Einstein condensation (BEC) at sufficiently low temperatures. On the other hand, in the high-density region where electrons and holes can form degenerate fermionic gases, a BCS-type condensation consisted of weakly bound e-h Cooper pairs has long been anticipated, referred to as the e-h BCS state, while its experimental verification has remained elusive over decades. We tackled this problem by the resonance excitation of 1S exciton across the excitonic Mott insulator-to-metal transition density [1-4]. The optical pump-probe spectroscopy shows that under the relatively low density region, the 1S exciton absorption line splits into two lines which are interpreted in terms of the dressed states(Rabi splitting) of excitons. The high-energy branch of the exctonic dressed states is shown to evolve into an pronounced absorption edge above the band-gap. Comparing the experimental result with a simulation based on semiconductor Bloch equations, we demonstrate that the dressed state in such a high-density region is viewed as e-h BCS state [5].

References

[1] T. Suzuki and R. Shimano, Phys. Rev. Lett. **103**, 057401 (2009).

[2] T. Suzuki and R. Shimano, Phys. Rev. Lett. **109**, 046402 (2012).

[3] T. Sekiguchi and R. Shimano, Phys. Rev. B **91**, 155202 (2015).

[4] T. Sekiguchi, T. Mochizuki, C. Kim, H. Akiyama. L. P. Pfeiffer, K. W. West, and R. Shimano, Phys. Rev. Lett. **118**, 067401 (2017).

[5] Y. Murotani, C. Kim, H. Akiyama. L. P. Pfeiffer, K. W. West, and R. Shimano, Phys. Rev. Lett. **123**, 197401 (2019).

Data Assimilation in Materials Science –
Crystal Structure Prediction Supported by Incomplete Experimental Data

Synge Todo
Department of Physics, University of Tokyo,
7-3-1, Hongo, Tokyo 113-0033, Japan
wisteria@phys.s.u-tokyo.ac.jp

Prediction of crystal structure from chemical composition has been a long-standing challenge in natural science. Although various numerical methods have been developed over last decades, it remains still difficult to numerically predict crystal structures comprising more than several tens of atoms in the supercell due to the many degrees of freedom, which increase exponentially with the number of atoms. Here, we propose a new "data assimilation" approach for crystal structure prediction from numerical simulations with support of X-ray diffraction experimental data [1]. We show that even if the experimental data is totally insufficient for conventional structure analysis, it can still support and substantially accelerate structure simulation. In particular, we formulate a cost function based on a weighted sum of interatomic potential energy and a penalty function referred to as "crystallinity", which is defined by using limited X-ray diffraction data. We apply this method to well-known polymorphs of SiO_2 and other materials with up to 108 atoms in the simulation cell and show that it reproduces the correct structures efficiently with very limited information of diffraction peaks.

We also propose a novel optimization method for the joint optimization of two or more cost functions [2]. Unlike the conventional joint optimization schemes, which try to find minima in a weighted sum of cost functions, the present algorithm explores search space for common minima shared by all the cost functions. Given a set of multiple cost functions that have qualitatively different distributions of local minima with each other, the proposed method finds the common minima with a high success rate without the help of any metaheuristics.

References

[1] N. Tsujimoto, D. Adachi, R. Akashi, S. Todo, S. Tsuneyuki, Phys. Rev. Materials **2**, 053801 (2018).
[2] D. Adachi, N. Tsujimoto, R. Akashi, S. Todo, S. Tsuneyuki, Comp. Phys. Comm. **241**, 92 (2019).

Implementation of an Inhomogeneous Large Spin-orbit Interaction at the Nanoscale

M. R. Delbecq[1], L. C. Contamin[1], T. Cubaynes[1], M. M. Desjardins[1], M. C. Dartialh[1], S. Rohart[2], A. Thiaville[2], Z. Legthas[3,1,4], A. Cottet[1], and T. Kontos[1]

[1]*Laboratoire de Physique de lEcole normale suprieure, ENS, Universit PSL, CNRS, Sorbonne Université, Université Paris-Diderot, Sorbonne Paris Cité, Paris, France*

[2]*Laboratoire de Physique des Solides, Université Paris-Sud et CNRS, Bt. 510, 91405 Orsay*

[3]*Centre Automatique et Systèmes, Mines-ParisTech, PSL Research University, Paris, France*

[4]*QUANTIC team, INRIA de Paris, 2 Rue Simone Iff, 75012 Paris, France*

matthieu.delbecq@phys.ens.fr

A strong spin-orbit interaction in low dimensional conductors is instrumental for the realization of non-trivial topological phases of matter. In particular, it is a necessary ingredient for the engineering of Majorana zero modes in condensed matter systems which could allow one to study excitations with particle/antiparticle duality and non-abelian statistics. Most of the experimental setups with nanoscale circuits use semiconducting nanowires with strong spin-orbit interaction connected to superconductors, under a finite magnetic field. Theoretical proposals have suggested autonomously inducing the spin-orbit coupling and the Zeeman field through a magnetic texture. This especially opens the possibility to release the constrain on the nanoconductor and use nearly ideal 1D conductor like carbon nanotubes. However revealing even a strong spin orbit interaction in a conventional transport experiment setup is challenging because of its weak effect in most of the phase diagram of an electronic system.

Here we show that it can be sensed thanks to the high spectroscopic resolution of circuit QED techniques. Specifically, we investigate a carbon nanotube double quantum dot (DQD) coupled to a microwave cavity and fabricated above a magnetic texture inducing a large synthetic spin orbit interaction. We probe the internal transitions of the DQD, which are resonant with the microwave resonator, with the cavity photons and reveal the spin-texture. The observed spectrum shows orbital dependent non-monotonic dispersions of the DQD energy levels with an external magnetic field with highly renormalized electron g factors up to 50 [1]. Alternatively, the coupling of the carbon nanotube to superconducting contacts also reveals a strong spin-orbit interaction of at least 1.1 meV through the evolution of spin textured Andreev bound states [2]. These findings are encouraging for the development of advanced experiments with Majorana zero modes, including microwave spectroscopy and braiding operations.

References

[1] L. C. Contamin *et al.*, in preparation.

[2] M.M. Desjardins *et al.*, Nat. Mater. **18**, 1060 (2019).

Non-equilibrium Fluctuations in Correlated Quantum Liquids

Kensuke Kobayashi
Institute for Physics of Intelligence (IPI) and Department of Physics, The University of Tokyo, Hongo 7-3-1, Bunkyo-ku, Tokyo 113-0033, Japan
Department of Physics, Osaka University, Machikaneyama 1-1, Toyonaka, Osaka 560-0043, Japan
kensuke@phys.s.u-tokyo.ac.jp

Quantum liquids are macroscopic ensembles of interacting particles dense enough for quantum statistics to manifest itself. For fermions, it is known that, around equilibrium, all the quantum liquids can be universally described within a single theory, so called Landau Fermi liquid theory. The idea is that they can be treated as an ensemble of free "quasi-particles". This conceptual framework has been applied to many physical systems, such as liquid helium 3, normal metals, heavy fermions, neutron stars, and cold gases, where their properties in the linear-response regime have been successfully described by the theory. However, non-equilibrium properties beyond this regime still remain a key issue of many-body physics.

Here, we show a precise experimental demonstration of Landau Fermi-liquid theory extended to the non-equilibrium regime in a 0-D system [1, 2, 3]. Combining transport and sensitive current noise measurements, we have identified the SU(2) and SU(4) symmetries of quantum liquid in a carbon nanotube tuned in the Kondo regime. We find that, while the electronic transport is well described by the free quasi-particle picture around equilibrium just as the Fermi liquid theory tells us, a two-particle scattering process due to residual interaction shows up in the non-equilibrium regime [4, 5, 6]. The effective charges e^*, which characterize this peculiar scattering, are determined to be $e^*/e = 1.7 \pm 0.1$ for SU(2) and $e^*/e = 1.45 \pm 0.1$ for SU(4) [1], being in perfect agreement with theory (e: electron charge) [4-6]. From these values, by using the extended Fermi-liquid theory, we obtain the interaction parameter "Wilson ratio" to be 1.95 ± 0.1 for SU(2) and 1.35 ± 0.1 for SU(4) cases [1, 6], which are the most precise determination of the Wilson ratios that has ever been demonstrated. This result, in perfect agreement with theory, provides a strong quantitative experimental background for further developments of the many-body physics. Moreover, we discovered a new scaling law for the effective charge, signaling as-yet-unknown universality in the non-equilibrium regime.

This achievement will open up a new way to explore quantum many-body physics through fluctuations, which stands on firm ground even out of equilibrium beyond the conventional Landau Fermi liquid theory.

References

[1] M. Ferrier, T. Arakawa, T. Hata, R. Fujiwara, R. Delagrange, R. Weil, R. Deblock, R. Sakano, A. Oguri, and K. Kobayashi, Nature Phys. 12, 230 (2016).
[2] M. Ferrier, T. Arakawa, T. Hata, R. Fujiwara, R. Delagrange, R. Deblock, Y. Teratani, R. Sakano, A. Oguri, and K. Kobayashi, Phys. Rev. Lett. **118,** 196803 (2017).
[3] T. Hata, R. Delagrange, T. Arakawa, S. Lee, R. Deblock, H. Bouchiat, K. Kobayashi, and M. Ferrier, Phys. Rev. Lett. **121,** 247703 (2018).
[4] E. Sela, Y. Oreg, F. von Oppen, and J. Koch, Phys. Rev. Lett. **97,** 086601 (2006).
[5] C. Mora, Phys. Rev. B **80,** 125304 (2009).
[6] R. Sakano, T. Fujii, and A. Oguri, Phys. Rev. B. **83,** 075440 (2011).

Microwave photons emitted by fractionally charged quasiparticles

R. Bisognin[1], H. Bartolomei[1], M. Kumar[1], I. Safi[2], J.-M. Berroir[1], E. Bocquillon[1], B. Placais[1], A. Cavanna[3], U. Gennser[3], Y. Jin[3], G. Fève[1],

[1]*Laboratoire de Physique de l'Ecole normale supérieure, ENS, Université PSL, CNRS, Sorbonne Université, Université Paris-Diderot, Sorbonne Paris Cité, Paris75005, France*

[2]*Laboratoire de Physique des Solides, Université Paris-Saclay, 91405 Orsay, France*

[3]*Centre de Nanosciences et de Nanotechnologies (C2N), CNRS, Univ. Paris-Sud, Université Paris-Saclay, 91120 Palaiseau, France*

Gwendal.feve@ens.fr

In a partially filled Landau Level, electron-electron interactions become dominant at high magnetic fields, leading to the manifestation of many-body states like the fractional quantum Hall (FQH) effect, where quasiparticle excitations carry fractional charges q=e/m, m = 3,5...[1].

The fractional charge has been successfully determined owing to low frequency shot noise measurements [2,3]. However, these methods suffer from several drawbacks. Firstly, the noise depends not only on the nature of the charge carriers, but also on the scattering properties of the conductor. Secondly, for specific filling factors of the fractional quantum Hall effect, these measurements do not provide an unambiguous determination of the charge, which is found to depend on external parameters such as electronic temperature or the conductor transmission [4]. Finally, being intrinsically low frequency, they cannot probe the characteristic frequency scales of quasiparticle transfer in contrast with high frequency measurements.

I will present the measurement of high frequency noise generated by the random transfer of fractional excitations through a potential barrier biased with a dc voltage V_{dc} [5]. At high frequencies (few GHz), the emitted noise can be interpreted as the generation of microwave photons in a coaxial measurement line weakly coupled to the sample. We observe that photons are only emitted when their frequency is smaller than the frequency threshold $f_J=qV_{dc}/h$ called the Josephson frequency [5,6] in analogy with the Josephson relation in superconductors. This threshold provides a direct determination of the fractional charge q.

High frequency characterizations of fractional excitations, in a complementary way to recent experiments of photo-assisted low frequency noise in the fractional quantum Hall regime, open the way to the exploration of the dynamical properties of anyons.

[1] R. B. Laughlin, Phys. Rev. Lett. **50**, 1395 (1983).
[2] R. de Picciotto, et al., Nature **389**, 162 (1997).
[3] L. Saminadayar, D.C. Glattli, Y. Jin, and B. Etienne, Phys. Rev. Lett. **79**, 2526 (1997).
[4] M. Dolev et al., Phys. Rev. B **81**, 161303(R) (2010).
[5] R. Bisognin et al. , Nature Communications **10**, 1708 (2019).
[6] M. Kapfer et al., Science **363**, 846, (2019).

Quantum Non-demolition Measurement of Single Spins

Seigo Tarucha
Center for Emergent Matter Science, RIKEN,
2-1 Hirosawa, Wako-shi, Saitama 351-0198 Japan
tarucha@riken.jp

In the context of quantum information technologies various techniques have been developed including manipulation, initialization, and readout of quantum states. Quantum non-demolition (QND) measurement is one of them and is a special type of projective measurement that does not impose any back action on the observable. The QND measurement has been developed for various systems of quantum optics, nuclear spins in diamond colour centres, superconducting circuits, and so on but not for electron spins in quantum dots until recently. We have recently used electron spins trapped by semiconductor quantum dots forming two spin qubits, data qubit and ancilla qubit to demonstrate the all-electrical QND measurement. In the measurement protocol we entangle the data qubit with the ancilla qubit via the exchange interaction [1] and then read out the ancilla in a single shot. We observe monotonous increase of the overall measurement fidelity by repeating the protocol [2]. The QND measurement is useful not only for improving the readout fidelity but also for implementing, measurement-based quantum algorithms including high-fidelity state preparation and quantum error correction. We indeed combine the QND measurement with feedback-control to demonstrate spin-state initialization with high fidelity.

References
[1] A. Noiri et al. Nature Commun. **9**, 5066 (2018).
[2] T. Nakajima et al. Nature Nanotechnol. **14**, 555 (2019).

Why Chemistry in Astrophysics

Satoshi Yamamoto
Department of Physics, The University of Tokyo,
7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan
yamamoto@phys.s.u-tokyo.ac.jp

In understanding the history of the Universe, exploring structure formation and physical evolution processes is a fundamental task in astrophysics. For instance, the formation of the first stars, the formation of galaxies, and the formation of stars and planets in galaxies have extensively been studied. At the same time, exploring the chemical evolution of matter in the Universe is also a fundamental task. Apart from the evolution of elemental abundances due to nucleosynthesis in stars, the most important and interesting issue is molecular evolution, which is directly related to understanding the material origin of the Solar System. How are molecules 5]formed in interstellar space? How large can molecules grow there? How are molecules incorporated into stars and planets? These questions represent the current frontiers in astronomy and astrophysics. Studies of structure formation processes and chemical evolution processes of matter are apparently two halves of the whole toward comprehensive understanding of the history of the Universe.

Stars and associated planetary systems are formed by the gravitational contraction of the interstellar gas. Our group is now investigating the chemical evolution during their formation processes with the state-of-the-art radio telescopes including ALMA (Atacama Large Millimeter/submillimeter Array). For the last decade, we have found that the chemical composition of the gas around the protostar shows significant diversity at a 1000 astronomical unit (au) scale (a parent gas cloud scale) to a few 10 au scale (a planetary system scale) [1-7]. This means that an initial chemical condition at the beginning of the planetary system formation is likely different from source to source. This result would be an important constraint when we consider whether our Solar system is common occurrence in the Universe. Moreover, we have found a drastic change in the chemical composition of the gas in the transition zone from an infalling-rotating envelope to a rotationally supported disk (Keplerian disk). This is likely caused by a combination of accretion shocks and protostellar heating [3,4]. Thus, the transition zone is highlighted by the chemical change. This is one of good examples showing the power of chemistry in astrophysical studies. The transition zone plays a crucial role in physical processes of star and planet formation. It can be responsible for discarding angular momentum of the infalling gas to form a disk structure. Its physical structure is likely unstable, which would cause a sporadic accretion onto a central star. Observations revealing a detailed structure of the transition zone is in progress.

References

[1] e.g., N. Sakai, N. and S. Yamamoto, Chemical Review 113, 8981 (2013).
[2] A.E. Higuchi et al. Astrophysical Journal Supplement Series, 236, 52 (2018).
[3] N. Sakai et al., Nature, 507, 78 (2014).
[4] Y. Oya et al., Astrophysical Journal, 824, 88 (2016).
[5] Y. Oya et al., Astrophysical Journal, 837, 174 (2017).
[6] Y. Okoda et al. Astrophysical Journal Letters, 864, L25 (2018)
[7] M. Imai et al., Astrophysical Journal Letters, 873, L21 (2019)

A Tale of Turbulence and Gravity

Edith Falgarone, Alba Vidal Garcia, Benjamin Godard et al.
Laboratoire de Physique de l'Ecole Normale Supérieure,
24 rue Lhomond, 75005 Paris, France
edith.falgarone@ens.fr

Turbulence, fed primarily by gravity, is ubiquitous in interstellar and intergalactic baryonic matter. It has so far escaped theory because it is supersonic, magnetized and its cascade pervades multi-phase media. Its dissipation, a key issue in the star and galaxy formation processes, remains elusive. A fundamental property of turbulent dissipation is its space-time intermittency, well studied theoretically and in flow experiments. While it can only be approached with dedicated numerical simulations in the case of magneto-hydrodynamical turbulence, its non-Gaussian statistical signatures have been detected in the velocity field of galactic interstellar matter [1]. This led to the prediction that specific molecules with highly endothermic formation can be quantitative markers of the dissipation rate of cosmic turbulence [2]. The recent discovery of one of these molecules in starburst galaxies at high redshifts has been a major surprise that has modified our perspective on galaxy growth in the early universe and reveals that cosmic turbulence is less dissipative than predicted by cosmological simulations [3].

References :
[1] Hennebelle & Falgarone, 2012, A&ARv, 20, 55
[2] Godard, Falgarone & Pineau des Forêts, 2014, A&A, 570, A27
[3] Falgarone, Zwaan, Godard et al., 2017, Nature, 548, 430

Cosmological Simulations of Galaxy Formation

Naoki Yoshida
Department of Physics, University of Tokyo,
7-3-1 Hongo, Bunkyo, Tokyo 113-0033, Japan
naoki.yoshida@ipmu.jp

We present the results from state-of-the-art computer simulations of the formation of galaxies in the universe. Our simulations follow the gravitational dynamics of dark matter and hydrodynamics, radiative transfer and chemistry of the inter-galactic and inter-stellar medium (ISM) in a self-consistent manner. In this talk, we focus on the large-scale distribution of galaxies and the inter-galactic hydrogen to be probed observationally by the next-generation telescopes such as NASA's James Webb Space Telescope. We then discuss details of the adopted models of ISM that capture the so-called baryonic physics such as star-formation and stellar feedback. We compare a few popular models and examine how the model choice affects the morphology of galaxies, to be compared with recent observations.

Finally, we present interesting applications of machine-/deep-learning for analysis of large observational data to be collected by future satellite missions. We use a large set of cosmological simulations and generate thousands of "mock observations" that are fed to conditional neural networks as training data set. Then the trained machine (network) can denoise two-dimentional matter distributions reconstructed from observations, and can also extract designated features such as the distribution of distant galaxies from infrared intensity maps. We discuss the future prospect for astroinformatics.

References

[1] S. Inoue and N. Yoshida. Mon. Not. Royal. Astron. Soc. **488**, 4400 (2019).
[2] K. Moriwaki, N. Yoshida, B. Ciardi, M. Eide, Mon. Not. Royal. Astron. Soc. **489**, 2471 (2019).

Dissecting the Molecular Mechanisms of Axonal Transport Through Single Molecule and Super-resolution Imaging

Yasushi Okada
Department of Physics, and Universal Biology Institute,
the University of Tokyo,
7-3-1 Hongo, Tokyo 113-0033, Japan
okada@phys.s.u-tokyo.ac.jp

Advancement of structural biology technologies such as cryo-EM has enabled us to visualize the atomic details of the proteins, the molecular machineries working in the living cells. However, there still remains a huge gap in our understanding of biological phenomena at the cellular level and the atomic details of the molecular machineries. One of the biggest hurdles to fill this gap would the lack of the dynamics and the context in those atomic structures. The atomic structure models are mostly frozen, and it is often difficult to understand the dynamics from those structures. Furthermore, the effects from the crowding environment of the cytoplasm have not been seriously examined. The concentration of protein in the cytoplasm is higher than 30%, which means that the cytoplasm is packed with proteins just like the rush-hour train, which would slow down the diffusion of molecules in the cytoplasm than in the dilute solution *in vitro*. This suggests that the reaction kinetics of enzymes and other molecular machineries would be affected by the crowded environment of the cytoplasm.

As a model system to examine this issue, we have been working on the axonal transport in the neurons. Neurons have a single long process, called axon, to send out the signal to the next target cells. Some axons in our body reach about 1 m in length, but the newly synthesized proteins in the cell body are packed into a 100-nm diameter vesicle and transported down in the axon to the terminal. Quite interestingly, the velocity of this transport vesicle is much faster than *in vitro*, although the crowded cytoplasm would pose more than 1000 times larger drag force on this transport vesicle than in the dilute solution *in vitro.* To solve this apparent paradox, we have been working on the development of several optical imaging technologies to examine the molecular details of this transport system. In this talk, I will discuss our recent results [1, 2]

References

[1] Shima, T., et al., J Cell Biol. **217**, 4164-83 (2018).
[2] Hayashi, K., et al., Mol Biol Cell. **29**, 3017-25 (2018).

In vitro recapitulation of biomimetic membranes: applications to synaptic transmission and membrane disruption in Parkinson disease

Frédéric Pincet
Laboratoire de Physique de l'ENS, Ecole Normale Supérieure,
24 rue Lhomond, 75005 Paris, France
frederic.pincet@ens.fr

We have recently developed a novel microfluidic setup in which stable biomimetic membranes can be fabricated [1]. Fast and sensitive electric (patch-clamp) and optical (Confocal microscopy and single particle tracking) measurements allow the monitoring of the membrane state in time. During my presentation, I will describe how this new biomimetic membrane is made and demonstrate its versatility in terms of composition and usage. Then I'll show how this membrane can be used on two examples related to neuronal function. First, I'll provide some hints on how sub-millisecond neurotransmission can be achieved accurately in time and space [2,3]. Second, I'll show some neuronal damage that occur during Parkinson disease: the aggregation of a protein on the neuron plasma membrane induces thinning, piercing and freezing of the membrane which disrupt neuronal function.

References

[1] P. Heo, S. Ramakrishnan, J. Coleman, J.E. Rothman, J.-B. Fleury, and F. Pincet, Small, **2019**, 1900725 (2019).
[2] F. Manca, F. Pincet, L. Truskinovsky, J.E. Rothman, L. Foret, M. Caruel, PNAS, 116: 2435-2442 (2019).
[3] S. Ramakrishnan, M. Bera, J. Coleman, S.S. Krishnakumar, F. Pincet, J.E. Rothman, FEBS Letters, 593 : 154- 162 (2019).

Understanding biological sensing and its optimality

Tetsuya J. Kobayashi
Institute of Industrial Science, the University of Tokyo,
4-6-1 Komaba, Tokyo 153-8505, Japan
tetsuya@mail.crmind.net

Almost all biological organisms are equipped with sensory systems with which they obtain the information about the environment. The performance of such a sensory system is crucial for the survival of organisms in the face of dynamic and unpredictable changes in the environment.

Bacterial chemotaxis and its associated sensory machinery have been the simplest model system. Each bacterium senses the external chemical gradient by actively moving in the gradient with stochastic activations of its sensory receptors for swimming either towards sources of attractants or away from those of repellants. To obtain the information about the direction of the gradient, cells have to process the dynamic change in the receptor activities out of the stochastic and noisy background activities. Even though biochemical models of bacterial chemotaxis have been proposed, the question of how the bacterial sensory system can extract information from noise remains elusive.

In this work, we address this problem using the theory of optimal filtering. By physically modelling the way how a bacterium is exposed to the gradient, we derive optimal sensing dynamics as the optimal filtering equation. By comparing the derived equation with a biochemical model of the bacterial chemotaxis, we demonstrate that such optimal sensing is structurally implemented in the bacterial sensory system. In addition, we show that our model based on optimal filtering can reproduce an experimentally observed functional relation in the system. We will also discuss potential applications of our approaches based on optimal filtering theory.

References

[1] T. J. Kobayashi, Phys. Rev. Lett. **104**, 228104 (2010).
[2] T. J. Kobayashi, Phys. Rev. Lett. **106**, 228101 (2011).

Some experiments with magnetic tweezers

Jean François Allemand
LPENS, ENS, Université PSL, CNRS, Sorbonne Université, Université de Paris,
24 rue Lhomond 75005 Paris France
jean-francois.allemand@ens.fr

Magnetic tweezers are a single molecule micromanipulation tool that allows to apply pN range forces, and torsion, on biomolecules, in particular DNA. I will illustrate two applications of magnetic tweezers in the study of:

1) PICH, a molecular motor translocating on double stranded DNA, that in conjunction with a topoisomerase, can generate positive torsion on DNA, which can be involved in the disjunction of sister centromeres [1],

2) the displacement and dissociation of oligonucleotides on a single stranded DNA forming a hairpin, a technique that can be used to obtain information on DNA sequence [2].

References

[1] Bizard et al., Nature Structural & Molecular Biology, pages267–274(2019)
[2] Ding et al., Nature Methods. **9**(4): 367–372 (2012).

Thermodynamics of Information

Takahiro Sagawa
Department of Applied Physics, University of Tokyo,
7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan
sagawa@ap.t.u-tokyo.ac.jp

In the nineteenth century, J. C. Maxwell considered a hypothetical being that can observe and manipulate individual atoms and molecules, leading to apparent violation of the second law of thermodynamics. Such a being was named Maxwell's demon and has been an issue of intense controversies; Nowadays, it is realized that information is the key concept to understand the role of the demon. In this decade, thermodynamics of information has attracted renewed attention from both the theoretical and experimental point of view [1]. Theoretically, a modern formulation of the second law has been established, where information contents and thermodynamic quantities, such as work and heat, are treated on an equal footing. Experimentally, Maxwell's demon has been realized by real experiments with various systems including colloidal particles, NMR, and superconducting qubits.

In this talk, I will focus on basic ideas in thermodynamics of information and the generalized second law that incorporates mutual information obtained by the measurement of the demon. I will also discuss how the “paradox” of Maxwell's demon is understood in light of the modern theory of thermodynamics. I will also briefly mention the recent progress in this field, especially possible application to biochemical signal transduction.

References

[1] J. M. R. Parrondo, J. M. Horowitz, T. Sagawa, Nature Physics **11**, 131-139 (2015).

ENS-UT Special Lectures on Physics

November 27-29, 2019

Hongo Campus, University of Tokyo

Lecture Program

November 27 (Wed) Faculty of Science, Building No.1, Room 207

9:30-11:30 Marc Mezard
"From Spin Glasses to Statistical Inference" (1)
13:00-16:00 Gwendal Feve
"Electronic Transport in Ballistic Quantum Conductors" (1)
16:30-18:30 Koji Hukushima
"Monte Carlo Approach to Statistical Physics and Bayesian Inference"

November 28 (Thu) Faculty of Science, Building No.1, Room 207

9:00-12:00 Marc Mezard
"From Spin Glasses to Statistical Inference" (2)
13:30-15:30 Seigo Tarucha
"Quantum Coherence and Entanglement of Electron Spins - Preparation, Manipulation and Detection"
16:00-18:00 Simona Cocco
"Statistical Physics, Inference and Applications to Biology" (1)

November 29 (Fri) Faculty of Science, Building No.1, Room 201b

9:00-12:00 Simona Cocco
"Statistical Physics, Inference and Applications to Biology" (2)
13:30-15:30 Gwendal Feve
"Electronic Transport in Ballistic Quantum Conductors" (2)
16:00-18:00 Chikara Furusawa
"Universal Biology of Evolution and Development: Theoretical and Experimental Approaches"

Lecture time: 5 hours for ENS professors, 2 hours for UT professors

How to get to your hotel

■Forest Hongo

address: 6-16-4 Hongo, Bunkyo-ku, 113-0033 Tokyo

phone: +81-(0) 3-3813-4408

+ Hotel Info: https://www.forest-hongo.com/en/location/

+ How to get to the hotel:

Haneda Airport – (monorail) – Hamamatsu-cho – (JR Yamanote Line) – Tokyo

--(Tokyo Metro Marunouchi Line: red) – Hongo san-chome – (10 min walk or taxi) --Hotel

(You can also take a taxi cab from Tokyo station; 20 min or so)

■Suigetsu Hotel

address: 3-3-21 Ikenohata, Taito-ku, 110-0008 Tokyo

phone: +81-(0)3-3822-4611

+ Hotel Info: https://ohgai.co.jp (Japanese web page only)

+ How to get to the hotel:

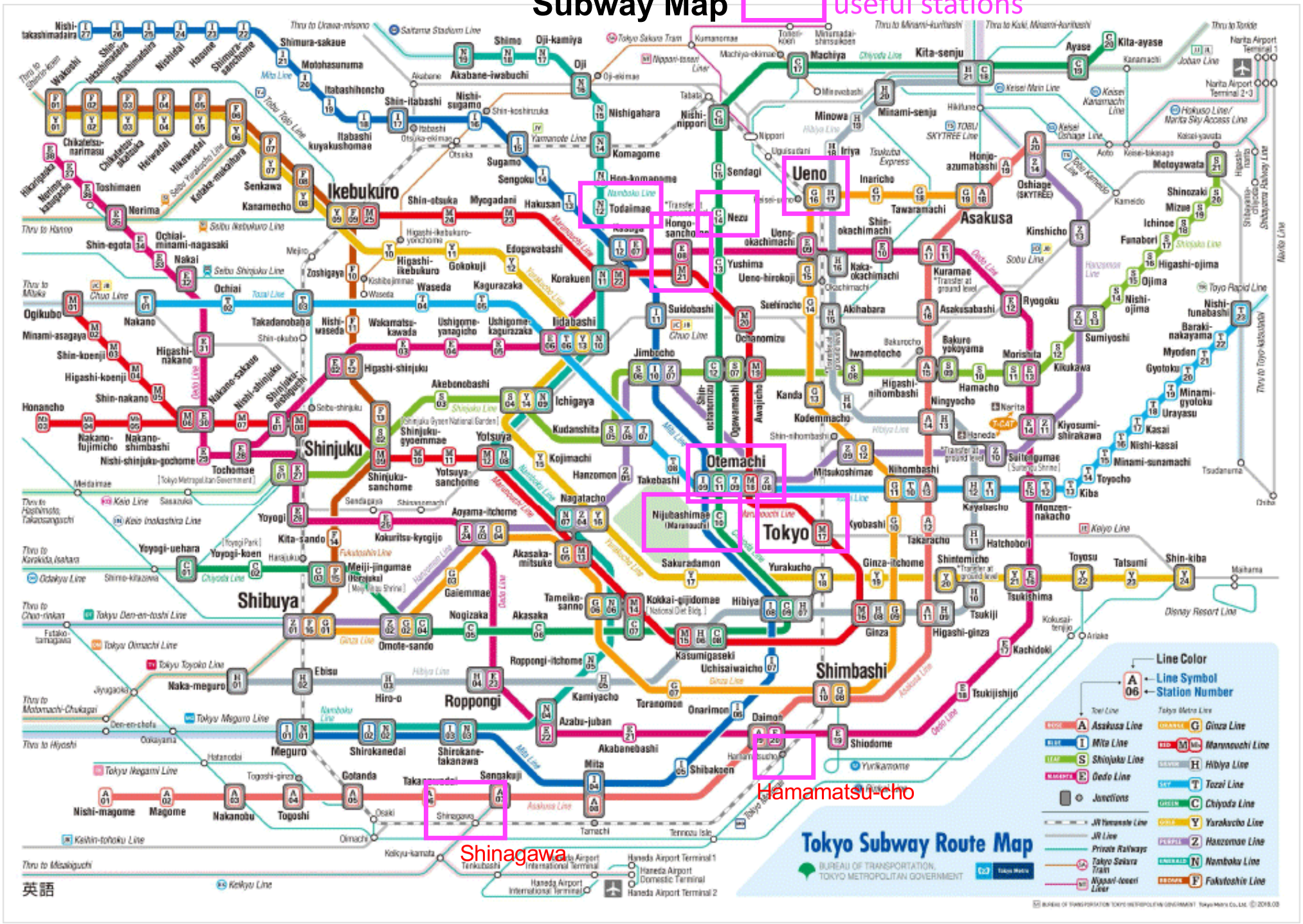
Haneda Airport – (monorail) – Hamamatsu-cho – (JR Yamanote Line) – Tokyo – (walk)

-- Nijubashi-mae or Otemachi – (Tokyo Metro Chiyoda Line: green) – Nezu --(walk)

--Hotel

Subway Map

useful stations



Some notice about the ENS-UT workshop/special lectures

Nov. 25 (Mon)	Workshop at Rm 1320, Faculty of Science Bldg 4
Nov. 26 (Tue)	Workshop at Rm 1320, Faculty of Science Bldg 4
Nov. 27 (Wed)	Special Lecture at Rm 207, Faculty of Science Bldg 1
Nov. 28 (Thu)	Special Lecture at Rm 207, Faculty of Science Bldg 1
Nov. 28 (Fri)	Special Lecture at Rm 201b, Faculty of Science Bldg 1

Suigetsu Hotel
0m
100m
200m
300m
N
Nezu Sta.(C14)
Subway Chiyoda Line
Ikenohata Gate
Faculty of Science
Bldg.4
(Workshop: Rm1320 3rd fl.)
Asano South
Gate
Asano Main
Gate
Yayoi
Gate
Yayoi Gate
Tetsu-mon Gate
TAXI
Yasuda Auditorium
clock tower
Faculty of Science Bldg.1
(Special Lectures:
Rm 207 on Nov. 27, 28
Rm 201b Nov. 29)
Tatsuoka
Gate
Nou-Seimon
Gate
Nishikata Gate
Main Gate
Hongo-dori Ave.
Akamon
(Red Gate)
Kaitoku Gate
Main Gate
Todaimae Sta.(N12)
Subway Namboku Line
Hongo-sanchome Sta.(E08)
Subway Oedo Line
Hongo-sanchome
Sta.(M21)
Subway
Marunouchi Line
Forest Hongo
For Kasuga Sta.(I12)
Subway Mita Line

D

安田講堂
Yasuda Auditorium

安田善次郎氏の寄附により大正14(1925)年に竣工。高さ39.7m。現在は式典・公開講座・五月祭などで使用されている。※登録有形文化財

E

三四郎池
Sanshirō Pond

正式名称は、旧加賀藩屋敷の「育徳園心字池」。夏目漱石の小説『三四郎』以来、この名で親しまれている。

F

広報センター
Information Center

学内外を問わず利用できる大学広報施設として平成7(1995)年に開設。建物は大正15(1926)年1月竣工。
※東京都選定歴史的建造物

1

レストラン アブルボア
Restaurant "abreuvoir"

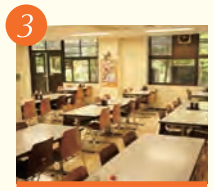
☎ 03-5840-8901【81245】
Weekdays/Sat. 11:00-15:00(L.O. 14:30)
17:00-21:00(L.O. 20:00)
Sun./Hols. -
▷ 向ヶ岡ファカルティハウス1階

2

ラウンジ アブルボア
Lounge "abreuvoir"

☎ 03-3813-0991【81246】
Weekdays 17:00-22:00
Sat. 17:00-22:00
Sun./Hols. -
▷ 向ヶ岡ファカルティハウス2階

3



生協 農学部食堂
Co-op dining hall in Yayoi section

☎ 03-5803-9761【27993】
Weekdays 11:00-20:00
Sat. -
Sun./Hols. -
▷ 農学部3号館 地下1階

7

生協 銀杏メトロ食堂
Cafe "Icho Metro"

☎ 03-3811-5297【27996】
Weekdays 11:00-20:00
Sat. -
Sun./Hols. -
▷ 法文2号館 地下1階

8

四季郷土料理 かどや山上亭
Japanese Restaurant "Kadoya Sanjō-Tei"

☎ 03-5841-2344【22344】
Weekdays 11:00-14:00
パーティ(予約のみ) 17:00-21:00
▷ 山上会館 地下1階

9

ティーラウンジ クレド
T-Lounge "CREDO"

☎ 03-5841-2328【22328】
Weekdays 09:30-15:30
パーティ(予約のみ) 17:00-21:00
▷ 山上会館 1階

13

イタリアン カポペリカーノ
Italian "Capo PELLICANO"

☎ 03-5841-1527【21527】
Weekdays/Sat. 11:00-15:00(L.O. 14:30)
18:00-22:00(L.O. 21:00)
Sun./Hols. -
▷ 医学部教育研究棟 13階

14

レストラン 椿山荘 カメリア
Restaurant Chinzan-sō Camellia

☎ 03-3812-2766
Weekdays/Sat. 11:00-15:00(L.O. 14:30)
17:00-22:00(L.O. 20:30)
Sun./Hols. -
▷伊藤国際学術研究センター 1階

15

サブウェイ
SUBWAY

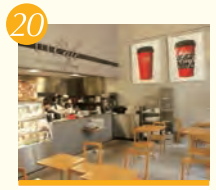
☎ 03-3814-4556【87539】
Weekdays 10:00-19:00
Sat. 11:00-16:00
Sun./Hols. - 不定休あり
▷ 工学部2号館 1階

19

タリーズコーヒー
Tully's Coffee

☎ 03-5842-2166
Weekdays 08:00-20:00
Sat. 09:00-20:00
Sun./Hols. 09:00-20:00
▷ 病院・入院棟A 1階

20



ユーティー・カフェ・ベルトレ・ルージュ
UT cafe BERTHOLLET Rouge

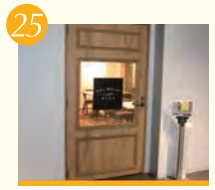
☎ 03-5841-0211
Weekdays/Sat. 10:00-20:00
(L.O. 19:30)
Sun./Hols. -
▷ 情報学環・福武ホール 1階

21

カフェ フォレスタ
Café FORESTA

☎ 03-3812-2766
Weekdays/Sat. 11:00-21:00
(L.O. 20:30)
Sun./Hols. -
▷伊藤国際学術研究センター 1階

25



麹町珈琲
Kojimachi Coffee

☎ 03-3812-1522
Weekdays 08:00-20:00
(L.O. 19:30)
Sat.Sun./Hols. -
▷南研究棟 1F

26

エ・プロント
É PRONTO

☎ 03-3817-0141
Weekdays 08:00-21:00
Sat. 11:00-19:00
Sun./Hols. 11:00-19:00
▷中央食堂2F

東京大学
THE UNIVERSITY OF TOKYO

〒113-8654
東京都文京区本郷 7-3-1
Tel: 03-3812-2111(代表)

7-3-1, Hongo, Bunkyo-ku,
Tokyo, 113-8654 Japan
Tel: +81-3-3812-2111
https://www.u-tokyo.ac.jp/

表紙写真提供：島 宏幸

Shops & Services

売店 Campus Store

	Weekdays	Sat.	Sun./Hols.
生協第二購買部 Co-op store No.2	08:00 ~ 20:00	11:00 ~ 16:00	11:00 ~ 16:00
生協浅野店 Co-op store in Asano section	10:00 ~ 18:00	-	-
生協農学部店 Co-op store in Yayoi section	10:00 ~ 18:00	-	-
生協グラウンドパンショップ Bread shop	10:00 ~ 14:00	-	-
生協赤門店 Akamon shop	10:00 ~ 17:00	-	-
Kショップガーデン K Shop Garden	24時間営業 Open 24 Hours		
ASUNARO(あすなろ) Asunaro	09:00 ~ 15:00	-	-

文具・パソコン等 Stationery, Computer Accessories etc

	Weekdays	Sat.	Sun./Hols.
生協第一購買部 Co-op store No.1	10:00 ~ 18:30	-	-

トラベルセンター Travel Center

	Weekdays	Sat.	Sun./Hols.
生協トラベルセンター Travel agency	10:00 ~ 18:00	-	-

書店・製本店 Bookstore,Bookbinders

	Weekdays	Sat.	Sun./Hols.
生協書籍部 Bookstore	10:00 ~ 19:00	10:00 ~ 17:00	-
岡田製本店 Okada Bookbinders	10:00 ~ 18:00	-	-

美容院 Hair Salon

	Weekdays	Sat.	Sun./Hols.
KITADOKO Kitadoko (不定休あり)	10:00 ~ 18:30	10:00 ~ 18:30	10:00 ~ 18:30
リ・リーフ Hair Salon "Le Leaf"	09:00 ~ 19:00	09:00 ~ 19:00	-

写真 Photo Studio

	Weekdays	Sat.	Sun./Hols.
新光社フォトスタジオ Shinkōsha	10:00 ~ 18:00	-	-

コンビニエンスストア Convenience Store

	Weekdays	Sat.	Sun./Hols.
ローソン 安田講堂店 / 龍岡門店 LAWSON Yasuda Auditorium Store / Tatsuoka Gate Store	24時間営業 Open 24 Hours		
ローソン 東大病院店 LAWSON University Hospital Store	08:00 ~ 18:00	-	-
ローソン 薬学部店 LAWSON Faculty of Pharmaceutical Sciences Store	10:30 ~ 19:00	-	-
ローソンストア100 工3号館店 LAWSON Faculty of Engineering Bldg.3 Store	07:30 ~ 21:00	07:30 ~ 21:00	07:30 ~ 21:00

銀行ATM Bank ATM (Automatic Teller Machine)

	Weekdays	Sat.	Sun./Hols.
安田講堂裏 Behind Yasuda Auditorium (SMBC, MUFG)	08:45 ~ 19:00	09:00 ~ 17:00	-
病院・外来診療棟内 Clinic	09:00 ~ 18:00	-	-
病院・入院棟A内 Ward A	00:00 ~ 24:00	00:00 ~ 22:00	08:00 ~ 21:00
赤門総合研究棟 Akamon General Research Bldg. (SMBC)	00:00 ~ 24:00	00:00 ~ 24:00	00:00 ~ 24:00

郵便局 Post Office

		Weekdays	Sat.	Sun./Hols.
東京大学内郵便局 (病院・入院棟A内) Campus Post Office (Ward A) Tel: 03-3812-9966	郵便 Mail Delivery	09:00 ~ 17:00	-	-
	貯金・保険 Savings and Insurance	09:00 ~ 16:00	-	-
	ATM Automatic Teller Machine	08:00 ~ 20:00	09:00 ~ 17:00	09:00 ~ 17:00

本郷地区キャンパスへの経路 Getting to the Hongō Campus

本郷三丁目駅（東京メトロ丸ノ内線 / 都営地下鉄大江戸線） Hongō-sanchōme Station (Subway Marunouchi Line / Subway Ōedo Line)	徒歩8分 8 minutes' walk.
湯島駅/根津駅（東京メトロ千代田線） Yushima Station or Nezu Station (Subway Chiyoda Line)	徒歩8分 8 minutes' walk.
東大前駅（東京メトロ南北線） Todaimae Station (Subway Namboku Line)	徒歩1分 1 minute's walk.

< バス利用 Bus >

御茶ノ水駅 Ochanomizu Station	学07東大構内行 / 茶51駒込駅南口行 / 東43荒川土手操車所前行
上野駅 Ueno Station	学01東大構内行
御徒町駅 Okachimachi Station	都02大塚駅前行 / 上69小滝橋車庫前行

東京大学
本郷地区キャンパス
ガイドマップ

THE UNIVERSITY OF TOKYO
HONGO SECTION CAMPUS
GUIDE MAP

東京大学
THE UNIVERSITY OF TOKYO

A

赤門
Akamon

正式名称は「旧加賀屋敷御守殿門」。文政10(1827)年建立。
※重要文化財

B

総合図書館
General Library

関東大震災後、ロックフェラーJr.の寄附を受け昭和3(1928)年に建設された。蔵書数は約129万冊。大学全体では約970万冊。(H31.3末現在)

C

正門
Main Gate

当時の浜尾総長の創意により、伊東忠太が設計した。青年の意気溌溂たる雄大な気概を表現。明治45(1912)年竣工。
※登録有形文化財

G

東京大学オフィシャルショップ コミュニケーションセンター
The University of Tokyo Official Shop "Communication Center"

☎ 03-5841-1039【21039】
Weekdays/Sat. 10:00-18:00
Sun./Hols. -
▷ 赤門北隣

H

総合研究博物館
University Museum

東京大学が創立以来収集してきた自然史や文化史等の学術標本を中心に、約400万点を所蔵しています。

I

健康と医学の博物館
Museum of Health and Medicine

医学部創立150周年を記念して設立。わが国の医学の発展における本学の貢献を紹介するとともに、医学・医療を紹介するトピック形式の企画展示を行う。

4

レストラン 日比谷松本楼
Restaurant "Hibiya Matsumoto-rō"

☎ 03-5805-5608【86054】
Weekdays 11:00-21:00
(L.O. 20:30)
Sat./Sun./Hols. -
▷ 工学部2号館 2階

5

生協 中央食堂
Chuo dining hall

☎ 03-3812-7336【27997】
Weekdays 08:00-21:00
Sat. 11:00-19:00
Sun./Hols. 11:00-19:00
▷ 中央食堂 地下

6

生協 第2食堂
Daini dining hall

☎ 03-3811-4889【27995】
Weekdays 10:30-14:30
Sat. -
Sun./Hols. -
▷ 第2食堂 2階

10

ブルークレール精養軒
Restaurant "Blue Clair Seiyōken"

☎ 03-5842-8261
Weekdays 11:00-20:00
Sat./Sun./Hols. 11:00-20:00
(L.O. 19:30)
▷ 病院・入院棟A 15階

11

食堂 三四郎
Restaurant "Sanshirō"

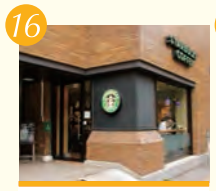
☎ 03-3811-1955
Weekdays 08:30-17:00
Sat. -
Sun./Hols. -
▷ 病院・外来診療棟 地下1階

12

FOOD HALL いちょう by ROYAL
Food Hall Icho by ROYAL

☎ 03-3868-2180【35907】
Weekdays 10:30-18:00(L.O. 17:30)
Sat.Sun./Hols. 11:00-15:00(L.O. 14:30)
▷附属病院入院棟A 1F

16



スターバックスコーヒー
Starbucks Coffee

☎ 03-5842-5716【87538】
Weekdays 08:00-20:00
Sat. 09:00-20:00
Sun./Hols. 09:00-20:00
▷ 工学部11号館 1階

17

ドトールコーヒーショップ 東京大学安田講堂前店
Doutor Coffee Shop

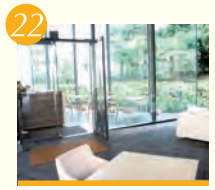
☎ 03-5684-7735
Weekdays 10:00-18:30
Sat. 10:30-17:00
Sun./Hols. -
▷ 理学部1号館 1階

18

ドトールコーヒーショップ 東大病院店
Doutor Coffee Shop

☎ 03-3813-3061
Weekdays 08:00-18:00
Sat. -
Sun./Hols. -
▷ 病院・外来診療棟 地下1階

22



廚菓子くろぎ
Café "Kurogi"

☎ 03-5802-5577
Open Hours 09:00-19:00
(L.O. 18:30)
不定休
▷情報学環・ダイワユビキタス学術研究館1階

23

カフェアグリ ワンオーワン
Café agri 101

☎ 03-3813-6101
Weekdays 08:30-17:30
Sat. -
Sun./Hols. -
▷農学部フードサイエンス棟 2階

24

カフェゆりの樹バイロイヤル
Café yurinoki by ROYAL

☎ 03-5880-7550
Weekdays 07:00-17:00
Sat. -
Sun./Hols. -
▷病院・入院棟B 1階

Sights

- A 赤門 Akamon
- B 総合図書館 General Library
- C 正門 Main Gate
- D 安田講堂 Yasuda Auditorium
- E 三四郎池 Sanshirō Pond
- F 広報センター Information Center
- G 東京大学オフィシャルショップ コミュニケーションセンター The University of Tokyo Official Shop "Communication Center"
- H 総合研究博物館 University Museum
- I 健康と医学の博物館 Museum of Health and Medicine

Restaurants

- 1 レストラン アブルボア Restaurant "abreuvoir"
- 2 ラウンジ アブルボア Lounge "abreuvoir"
- 3 生協 農学部食堂 Co-op dining hall in Yayoi section
- 4 レストラン 日比谷松本楼 Restaurant "Hibiya Matsumoto-rō"
- 5 生協 中央食堂 Chuo dining hall
- 6 生協 第2食堂 Daini dining hall
- 7 生協 銀杏メトロ食堂 Cafe "Icho Metro"
- 8 四季郷土料理 かどや山上亭 Japanese Restaurant "Kadoya Sanjo-Tei"
- 9 ティーラウンジ クレド T-Lounge "CREDO"
- 10 ブルークレール精養軒 Restaurant "Blue Clair Seiyoken"
- 11 食堂 三四郎 Restaurant "Sanshirō"
- 12 FOOD HALL いちょう by ROYAL Food Hall Icho by ROYAL
- 13 イタリアン カポペリカーノ Italian "Capo PELLICANO"
- 14 レストラン 椿山荘 カメリア Restaurant Chinzan-sō Camellia

Cafes

- 15 サブウェイ SUBWAY
- 16 スターバックスコーヒー Starbucks Coffee
- 17 ドトールコーヒーショップ東京大学安田講堂前店 Doutor Coffee Shop
- 18 ドトールコーヒーショップ 東大病院店 Doutor Coffee Shop
- 19 タリーズコーヒー Tully's Coffee
- 20 ユーティー・カフェ・ベルトレ・ルージュ UT cafe BERTHOLLET Rouge
- 21 カフェ フォレスタ Café FORESTA
- 22 厨菓子くろぎ Café "Kurogi"
- 23 カフェアグリ ワンオーワン Café agri 101
- 24 カフェゆりの樹バイロイヤル Café yurinoki by ROYAL
- 25 麹町珈琲 Kojimachi Coffee
- 26 エ・プロント È PRONTO

0m 100m 200m
0分 1分 2分 3分

不忍池 Shinobazu-no-ike Pond

不忍通り Shinobazu-dori Ave.

千代田線 湯島駅 Chiyoda L. Yushima Sta. C13 出口1 出口2 出口3 出口4

千代田線 根津駅 Chiyoda L. Nezu Sta. C14 出口1 出口2 EV

池之端門 Ikenohata Gate

ポスト Post

浅野キャンパス Asano Section

- 工12号館 Eng.12
- 理3号館 Sci.3
- 生協浅野店 Co-op store in Asano section
- 弥生二丁目遺跡
- 工9号館 Eng.9
- 工10号館 Eng.10
- アイソトープ総合センター Isotope Center
- 向岡記碑
- 情報基盤センター Information Technology Center
- 浅野南門 Asano South Gate
- 低温センター Cryogenic Research Center
- 浅野正門 Asano Main Gate
- 武田先端知ビル Takeda Bldg.
- 武田ホール Takeda Hall
- 弥生式土器発掘ゆかりの地
- 弥生門 Yayoi Gate
- 鞠通り Kototoi-dori Ave.

本郷キャンパス Hongō Section

- 病院・東研究棟 East Clinical Research Bldg.
- 病院・臨床試験棟 Clinical Research Ward
- 病院・最先端臨床研究センター Advanced Clinical Research Center
- 分子ライフイノベーション棟 Molecular & Life Innovation Bldg.
- 病院・入院棟B Ward B
- 病院・入院棟A Ward A
- 環境安全研究センター Environmental Science Center
- 病院・中央棟東 Central Bldg. (East Wing)
- ATM
- 東京大学内郵便局 Campus Post Office
- 相良知安先生記念碑
- ベルツの庭石
- 病院・臨床研究棟A Clinical Research Bldg.A
- 病院・中央棟南 Central Bldg. (South Wing)
- リ・リーフ Hair Salon "Le Leaf"
- Kショップガーデン K Shop Garden
- 生協トラベルセンター Travel Agency
- 病院・中央診療棟1 Central Clinical Service Bldg.1
- 病院・中央診療棟2 Central Clinical Service Bldg.2
- 鉄門 Tetsu-mon (Gate)
- 生協書籍部 Bookstore
- 病院・第一研究棟 First Research Bldg.
- 青山胤通像
- 佐藤三吉像
- 病院・管理・研究棟 Administration & Research Bldg.
- LAWSON
- ATM
- あすなろ Asunaro
- 病院・外来診療棟 Clinic
- 医4号館 Med.4
- 医・健康と医学の博物館 Museum of Health and Medicine
- 病院・南研究棟 South Clinical Research Bldg.
- 山上会館龍岡門別館 Sanjo Conference Hall Tatsukomon Annex
- LAWSON
- 理1号館(東棟) Sci.1 (East)
- 理7号館 Sci.7
- ダイバース像
- 理・化学館 Chemistry Bldg.
- 生協グラウンドパンショップ Bread shop
- 理1号館 (中央棟) 小柴ホール Sci.1 (Center) Koshiba Hall
- ノーベル物理学賞受賞展示
- 理4号館 Sci.4
- 理1号館 (西棟) Sci.1 (West)
- 御殿下記念館 Gotenshita Memorial Arena
- 御殿下グラウンド Gotenshita Ground
- 学生支援センター Student Support Center
- スクリバ像 ベルツ像
- ミュルレル像
- 下山順一郎像
- 七徳堂 Shichitokudo
- 医・総合中央館(図書館) Med. Library
- 薬学系総合研究棟 Pharm. Sciences Research Bldg.
- 薬学系研究科 先端創薬棟 Frontier Sciences for Drug Discovery Bldg.
- 本部棟 Administration Bureau
- 第2本部棟 Administration Bureau Bldg.2
- 広報センター Information Center
- 龍岡門 Tatsuoka Gate
- 医5号館 Med.5
- 本富士警察署 Motofuji Police Station
- 本郷消防署 Hongō Fire Station
- アントレプレナープラザ Entrepreneur Plaza
- 医・生命科学実験棟 Bioscience Research Bldg.
- 医3号館 Med.3
- 産学連携プラザ UCR Plaza
- 情報学環・ダイワユビキタス学術研究館 i-Daiwa Ubiquitous Computing Research Bldg.
- 春日門 Kasuga Gate
- Sunkus
- 明治天皇行幸記念碑
- 懐徳館 Kaitokukan
- Seven-Eleven
- 医・教育研究棟 Med. Experimental Research Bldg.
- 育徳堂(弓道場) Ikutokudo (Japanese Archery Range)
- 医2号館本館 Med.2
- 医1号館 Med.1
- 山上会館 Sanjo Conference Hall
- 浜尾新像
- 三四郎池 Sanshiro Pond
- 隈川宗雄像
- 医・国際共同研究棟 International Research Center
- 社会科学研究所 Inst. of Social Science
- 赤門総合研究棟 Akamon General Research Bldg.
- 教育学部 Edu.
- 経済学研究科棟 Econ. Research Bldg.
- 国際学術総合研究棟 International Academic Research Bldg.
- 東洋文化研究所 Inst. for Advanced Studies on Asia
- 理2号館 Sci.2
- 生協赤門店 Akamon shop
- 総合研究博物館 University Museum
- 懐徳門 Kaitoku Gate
- 伊藤国際学術研究センター / 伊藤謝恩ホール Ito International Research Center / Ito Hall
- 経済学研究科学術交流棟・小島ホール Econ. Research Annex (Kojima Hall)
- 法学政治学系総合教育棟 School of Law Bldg.
- 情報学環・福武ホール i-i-Fukutake Hall
- 東京大学オフィシャルショップ コミュニケーションセンター The University of Tokyo Official Shop "Communication Center"
- NATURAL LAWSON
- 本郷郵便局 Hongō Post Office
- Family Mart
- 交番 Police
- 本郷四郵便局 Hongō 4 Post Office

弥生キャンパス Yayoi Section

- 向ヶ岡ファカルティハウス Mukougaoka Faculty House
- 生命科学総合研究棟 Life Sciences Research Bldg.
- 生命科学総合研究棟B Life Sciences Research Bldg.B
- 生物生産工学研究センター Biotechnology Research Center
- 農7号館B棟 Agr.7B
- 農7号館A棟 Agr.7A
- 農6号館 Agr.6
- 農学生命科学図書館 Agr.Library
- 農5号館 Agr.5
- 動物医療センター Veterinary Medical Center
- ヤンソン像
- フードサイエンス棟 Food Science Bldg.
- I-REF棟 I-REF Bldg.
- 地震研究所1号館 ERI 1
- 地震研究所2号館 ERI 2
- 地震研究所3号館 ERI 3
- 農3号館 Agr.3
- 生協農学部店 Co-op store in Yayoi section
- 総合研究棟 General Research Bldg.
- 定量生命科学研究所 Inst. for Quantitative Biosciences
- 朱舜水記念碑
- 農2号館 Agr.2
- 農1号館 Agr.1
- 上野英三郎博士とハチ公
- 農学資料館 Agr. and Life Sciences Museum
- 弥生講堂アネックス Yayoi Auditorium Annex
- 弥生講堂・一条ホール Yayoi Auditorium (Ichijo Hall)
- 農正門 No-seimon (Gate)
- 出口1 出口2 EV
- 南北線 東大前駅 Namboku L. Todaimae Sta. N12
- 都02 上69 都営バス
- 東51 東43 都営バス
- Seven-Eleven

- 工13号館 Eng.13
- 工3号館 Eng.3
- LAWSON Store 100
- ノーベル物理学賞記念植樹
- 山川健次郎像
- 工4号館 Eng.4
- 工2号館 Eng.2
- 工7号館 Eng.7
- 工8号館 Eng.8
- 工6号館 Eng.6
- 工5号館 Eng.5
- 工1号館 Eng.1
- 工・ものづくり実験工房 Monozukuri Lab.
- 工14号館 Eng.14
- 工11号館 Eng.11
- 古市公威像
- 三好晋六郎像
- ウェスト像
- コンドル像
- 工・列品館 Reppin-kan
- 法3号館 Law 3
- 法4号館 Law 4
- 史料編纂所 Historiographical Inst.
- 法文1号館 Law & Let.1
- 法文2号館 Law & Let.2
- 文3号館 Let.3
- 西片門 Nishikata Gate
- 本郷通り Hongo-dori Ave.
- 正門 Main Gate
- Family Mart
- LAWSON Store 100
- 東51 東43 都営バス
- 本郷郵便局 Hongo Post Office

- 都02 上69 都営バス
- 出口5 出口4 出口3 出口2 出口1 EV
- E 08 大江戸線 本郷三丁目駅 Ōedo L. Hongō-sanchōme Sta.
- M 21 丸ノ内線 本郷三丁目駅 Marunouchi L. Hongō-sanchōme Sta.
- Family Mart
- 交番 Police

掲載されている情報は令和元年5月現在のものです。年末年始・夏季休暇・イベント等により一部変更が生じる場合もございます。
The information contained in this map is correct as of May 2019. Opening hours may change without notice.