Keisuke Fujii

CONTACT INFORMATION

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EDUCATION

Kyoto university, Kyoto, Japan

Graduate student — April 2007 to March 2012

Ph.D., Engineering, March 2012
Thesis: *Spectroscopic Study on Hydrogen Recycling in Large Helical Device* Advisors: Masahiro Hasuo, Prof.

RESEARCH EXPERIENCE / REPRESENTATIVE PAPERS

Optical Diagnostics in a Large Fusion Facility
13-years' experience of high-performance spectrometer development, installation, and maintenance for fusion plasma diagnostics in a Japanese Large Fusion Facility, LHD (e.g., 10^6 dynamic-range spectrometer, wideband and high-resolution echelle spectrometer)

Keisuke Fujii, et al.,
Development of a high dynamic range spectroscopic system for observation of neutral hydrogen atom density distribution in Large Helical Device core plasma,
Review of Scientific Instruments, **85**, 023502 (2014)
10.1063/1.4863650,

Theoretical Modeling of Atomic Processes and Kinetics in Fusion Plasmas
Full experience of theoretical modeling for atomic and molecular processes in high and low-temperature plasmas, and their transport.

Keisuke Fujii, et al.,
Study of neutral hydrogen transport in LHD core plasmas based on high dynamic-range Balmer-α spectroscopy
Nuclear Fusion **55**, 063029 (2015)
10.1088/0029-5515/55/6/063029,

Statistical Modeling of Atomic Structure and Processes
Pioneering the statistical physics for atomic structure and reactions networks in plasmas.

Keisuke Fujii and Julian C. Berengut,
Simple explanation for the observed power law distribution of line intensity in complex many-electron atoms,
Physical Review Letters **124**, 185002 (2020)
10.1103/PhysRevLett.124.185002,

Keisuke Fujii and Julian C. Berengut,
Power-law intensity distribution of γ-decay cascades: nuclear structure as a scale-free random network,
Physical Review Letters **126**, 102502 (2021)
10.1103/PhysRevLett.126.102502,

57 papers in total including 16 first- and corresponding-authored papers.
One paper is under the review in *Physical Review Letters*
https://arxiv.org/abs/2103.04463

See *list of publications* for the full list of publications.

Job Experience

Assistant Professor April 2012 to present
Graduate School of Engineering, Kyoto University

Lecturer
- Practice of Basic Informatics 2014–2021
- Mechanical and System Engineering Experiment 2012–2021

Lab staff
- Supervised 15 master students
- Supervised 15 graduate students

Visiting scientist September 2018 to September 2019
Max-Planck Institute for Nuclear Physics, Heidelberg, Germany

Visiting student March 2010 to June 2010
Quantum theory project, University of Florida, US

Invited Talks

- Power-Law Distribution of Emission Lines from Many-Electron Atoms
  21st International Conference on Atomic Processes in Plasmas
  (planned in 12-16 April 2021, but postponed)
- Bayesian Inference for the LHD Experiment Data
  IAEA Technical Meeting on Uncertainty Assessment and Benchmark Experiments for Atomic and Molecular Data for Fusion Applications
  (19-21 December 2016, IAEA Headquarters, Vienna, Austria)
- Neutral Hydrogen Dynamics in Fusion Core Plasmas Revealed by High Dynamic Range Balmer-α Spectroscopy
  9th International Conference on Atomic and Molecular Data and Their Applications
  (21-25 September 2014 Jena, Germany)

Grants

- Grant-in-Aid for Research Activity start-up (2012-2013, ¥ 3,000,000)
  Development of ultra-high dynamic rage spectroscopic method for evaluation of neutral hydrogen density distribution in fusion core plasmas (principal investigator)
- Grant-in-Aid for Challenging Exploratory Research (2014-2016, ¥ 3,640,000)
  Measurement of ion temperature spatial structure in high temperature plasmas based on Balmer-alpha spectrum (principal investigator)
- Joint Research by the National Institutes of Natural Sciences (NINS) (2018, ¥4,000,000)
  Extraction of latent structures from high dimensional time-series data (principal investigator)

Awards

Young Scientist Best Presentation Award November 2013
9th Asia Plasma Fusion and Fusion Association Conference

Young Scientist Best Presentation Award November 2014
Plasma 2014

References

**** ****
Professor in **********
E-mail: ********@********

Software Skills

- Experience to develop libraries through open-source contribution including `flexible-atomic-code`, `numpy` and `dask`.
- A core development member of `xarray`.
- Leading some Python libraries on GitHub `https://www.github.com/fujiisoup`.
- Sufficient knowledge for C, C++, LabView

Research experience

Here, I will introduce my representative achievements. I have been working on 1.development of novel sensing methods for fusion physics and 2.pioneering statistical physics for complex atomic structure and atomic reactions in plasmas (Fig. 1).

Development of novel sensing methods for fusion physics

One of my expertise is to develop new plasma diagnostics. I believe that new diagnostics is almost always realized by new instruments that perform two orders of magnitude better than traditional ones in some aspects.

The most representative of my achievements is the development of high dynamic range spectroscopy systems. I realized a spectroscopy system with a dynamic range of 10^6, which is more than two orders of magnitude higher than the conventional ones, to measure a very weak emission from neutral hydrogen atoms in ultra-high temperature fusion core plasmas [paper 11, 12, Fig. 1**a**]. I have also developed a multi-wavelength high-resolution spectrometer [paper 13,15,16] and an echelle spectrometer [paper 9,23, Fig. 1**b**], both of which perform high-resolution spectroscopy in multiple wavelength regions simultaneously.

A novel sensing technology is useful only if it is followed by effective data analysis. However, in the case of very new sensing methods, such as high dynamic range measurement, effective data analysis methods themselves often do not exist. My research style is characterized by the simultaneous development of new data analysis methods to assist the new sensing methods. This sometimes requires the use of not only classical information theory, but also more advanced information theory, including Bayesian statistics and neural networks.

By combining these theories, for example, I realized for the first time the measurement of neutral hydrogen atom density in fusion core plasmas, which had been thought to be unrealizable because of its small density [Paper 8, 11, 12]. **These results have had an impact on the field of plasma and nuclear fusion. In fact, I was awarded the Young Scientist Best Presentation Award at two international conferences for this achievement**.

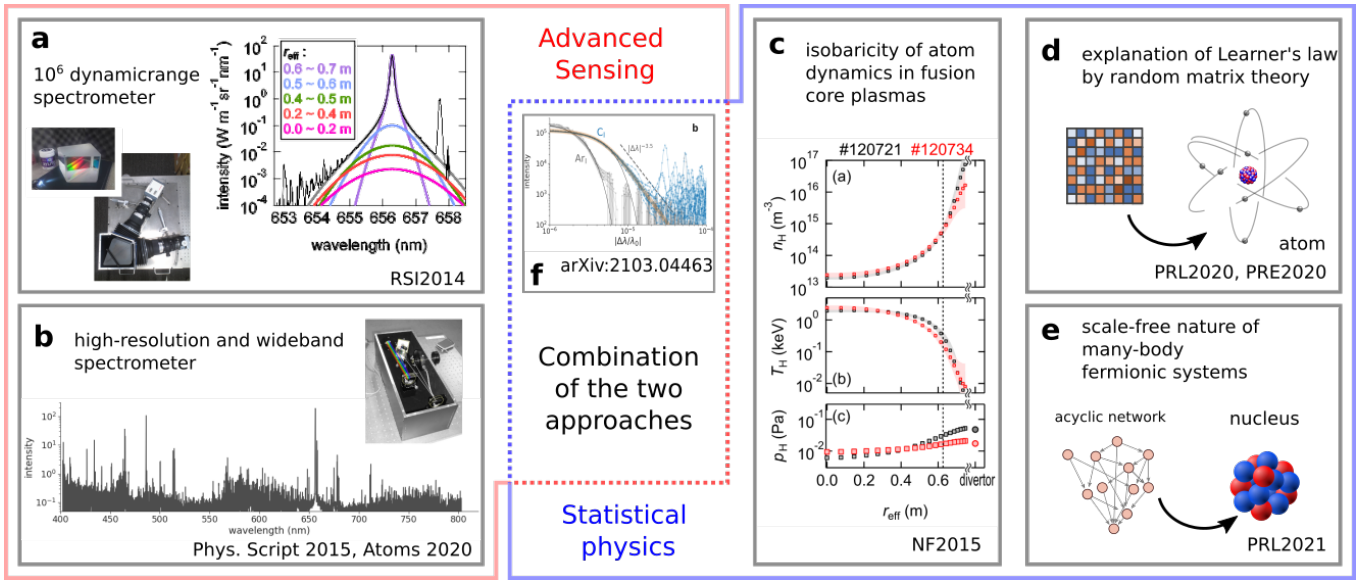

Fig.1 A schematic illustration of my research experience. I have been working for (a,b) the development of advanced sensing methods and (c, d, e) statistical modeling of complex physical systems. (f) More recently, I am combining two strategies and producing even more impactful results.

Pioneering statistical physics for atomic structure and atomic reactions in plasmas

The other strategy of my works is to pioneer statistical physics for plasma- and atom-related fields. Typically, statistical modeling has been used in the fields of statistical data analysis and machine learning. For example, to understand the effect of the lock-down, a linear relationship between the presence or absence of the lock-down and human flow is used to estimate the effect from the data. Of course, the relationship must be much more complicated and many other things should affect. However, this crude approximation is very useful to clarify and understand the causality.

On the other hand, in the fusion plasmas and atomic physics communities, which I have been contributing to, I think the mainstream research is aimed at avoiding approximations and trying to be as accurate as possible in discussions and simulations. However, I realized through my research experience that by including all the effects the system becomes more black-boxed and more difficult for us to understand the causality involved. For that reason, I have started investigating statistical physics for these fields and tried to extract what is essential in the systems. Particularly by adopting the random approximation for complex phenomena, we are able to extract the essential physics in the system.

Neutral atom dynamics in fusion core plasmas

One of my achievements of the statistical modeling is the investigation of the neutral atom dynamics in fusion core plasmas [paper 3, published in *Nuclear Fusion*, Fig.1 **c**].

In fusion plasmas, neutral hydrogen atoms (or their isotopes) can penetrate even into very high temperature core plasmas through the repetition of charge exchange collisions with hydrogen ions. As many processes have been believed to affect this dynamics, the mainstream for this topic is based on the Monte-Carlo method including as many effects as possible.

In this work, I have approximated the atom dynamics in fusion core plasmas by the Boltzmann equation. I found that **the atom dynamics nearly follows the isobaric process, where the atom pressure is almost the same between the edge and core regions**. Therefore, the depletion of atoms in the core plasmas should be understood by the temperature increase in the core rather than the ionization by electron impact.

A simple explanation of the intensity power-law of many-electron atom emission

Another representative achievement is the first explanation of empirical law for emission line statistics of many-electron atoms [papers 2, 5, Fig.1**d**]. The emission lines from transition metals and lanthanides (e.g., iron and tungsten) are very complex because of nonlinear many-body interaction of valence electrons. There is one empirical law for the emission line statistics, which was reported in 1982. The law states that the number of emission lines follows a power-law of their intensities. Many groups have been working to theoretically explain this law, however, none of them succeeded.

In paper 2, I succeeded to explain this law for the first time, by drastically approximating the energy structure of many-electron atoms in the probabilistic manner. The fact that a 40-years old mystery was solved by statistical modeling with just a few lines of equations was greeted with great surprise. **A referee in *Physical Review Letters*, the premier journal in the field of physics, praised it as "(This paper) provides a surprisingly simple and elegant analytical explanation for Learner's well-known observation."**

Furthermore, based on this research, I have proposed a new research project *"investigating the structure of quasi-continuum atomic spectra UTA based on high-resolution spectroscopy and statistical theory",* which has been selected as a Grant-in-Aid for Scientific Research A in 2021 (PI: Izumi Murakami, Project No.: 21H04460, Total Amount:

42,640 thousand yen). As such, my investigation is propagating to the plasma and atomic physics field.

An untrivial relation between many-electron atoms, heavy nuclei, and scale-free networks

One of the advantages of statistical modeling is that it allows one to describe the essentials of a system in a simple mathematical forms. In doing so, it is often possible to find similarities with other systems that appear to be quite different. The best example of this is the discovery of the scale-free nature of the γ-decay spectrum of atomic nuclei. In this study, I found that the emission from nuclei (γ-rays), whose energy scale is more than six orders of magnitude larger than that of atoms, also follows a power law. However, more importantly, I pointed out that the structure of many-electron atoms and nuclei can be regarded as an acyclic scale-free network. **It is counterintuitive that the unknown properties were derived by statistical modeling from very well known data of γ-decay spectra. This work was also published in *Physical Review Letters*** [paper 1, Fig.1**e**].

Acyclic scale-free networks can be found in various phenomena such as citation relationships in scientific papers, genetic phylogenetic trees, and food chain trees. By using statistical modeling, we are able to find non-trivial common denominators lying between different phenomena, which can dramatically deepen our understandings.

Combination of sensing and statistical modeling

I start combining my two main research strategies, the development of new sensing methods and statistical modeling. One of such topics is the velocity distribution of radicals in plasmas, such as hydrogen or oxygen atoms in fusion edge plasmas, which has been known to have a non-thermal shape but their analytical description is yet unclear.

In [unpublished paper 1, currently under review in *Physical Review Letters*], by boldly approximating the collision theory by statistical modeling, I derived that the velocity distribution robustly becomes a power-law distribution, and analytically unveiled its power-law exponent. I have also experimentally verified this theory using high-resolution and high-dynamic-range measurements, which is one of my specialties.

As mentioned above, in the fields of plasma and fusion physics and atomic physics, which are recognized as hard sciences, first-principles approaches are still the mainstream, and statistical modeling is rarely used. By coordinating the development of new sensing methods with statistical modeling, I am now in a position to continuously produce impactful results in this field.

Research plan

NOTE! RESEARCH PLAN WAS HERE BUT IS OMITTED NOW

List of selected papers

- **Power-Law Intensity Distribution of γ -Decay Cascades: Nuclear Structure as a Scale-Free Random Network**
  Keisuke Fujii, Julian C. Berengut
  Physical Review Letters **126,** 102502 (2021)
  10.1103/PhysRevLett.126.102502

- **Simple Explanation for the Observed Power Law Distribution of Line Intensity in Complex Many-Electron Atoms**
  Keisuke Fujii, Julian C. Berengut
  Physical Review Letters **124,** 185002 (2020)
  10.1103/physrevlett.124.185002

- **Study of neutral hydrogen transport in LHD core plasmas based on high dynamic-range Balmer-α spectroscopy**
  K. Fujii, M. Goto, S. Morita, The LHD Experiment Group
  Nuclear Fusion **55,** 063029 (2015)
  10.1088/0029-5515/55/6/063029

- **Development of a high dynamic range spectroscopic system for observation of neutral hydrogen atom density distribution in Large Helical Device core plasma**
  K. Fujii, S. Atsumi, S. Watanabe, T. Shikama, M. Goto, S. Morita, M. Hasuo
  Review of Scientific Instruments **85,** 023502 (2014)
  10.1063/1.4863650

List of papers (first- and corresponding-author)

1. **Power-Law Intensity Distribution of γ -Decay Cascades: Nuclear Structure as a Scale-Free Random Network**
   Keisuke Fujii, Julian C. Berengut
   Physical Review Letters **126,** 102502 (2021)
   10.1103/PhysRevLett.126.102502

2. **Population kinetics of many-electron atoms in ionizing plasmas studied using a continuous collisional radiative model**
   Akira Nishio, Julian C. Berengut, Masahiro Hasuo, **Keisuke Fujii**
   Physical Review E **102,** 053211 (2020)
   10.1103/PhysRevE.102.053211

3. **Simple Explanation for the Observed Power Law Distribution of Line Intensity in Complex Many-Electron Atoms**
   Keisuke Fujii, Julian C. Berengut
   Physical Review Letters **124,** 185002 (2020)
   10.1103/physrevlett.124.185002

4. **Robust Regression for Automatic Fusion Plasma Analysis Based on Generative Modeling**
   K. Fujii, C. Suzuki, M. Hasuo

IEEE Transactions on Plasma Science **47,** 3305-3314 (2019)
10.1109/TPS.2019.2921073

5. **Machine Learning of Noise in LHD Thomson Scattering System**
Keisuke Fujii, Ichihiro Yamada, Masahiro Hasuo
Fusion Science and Technology **74,** 57-64 (2018)
10.1080/15361055.2017.1396179

6. **Experimental evaluation of fractional abundance data for W23+–W28+**
Keisuke Fujii, Daiji Kato, Nobuyuki Nakamura, Motoshi Goto, Shigeru Morita, Masahiro Hasuo
Journal of Physics B: Atomic, Molecular and Optical Physics **50,** 055004 (2017)
10.1088/1361-6455/50/5/055004

7. **Data-driven sensitivity inference for Thomson scattering electron density measurement systems**
Keisuke Fujii, Ichihiro Yamada, Masahiro Hasuo
Review of Scientific Instruments **88,** 013508 (2017)
10.1063/1.4974344

8. **Inversion Methods of the Balmer-α Line Profile for Hydrogen Atom Density Evaluation in High-Temperature Plasmas**
Keisuke Fujii, Motoshi Goto, Shigeru Morita, Masahiro Hasuo
Fusion Science and Technology **69,** 514-525 (2016)
10.13182/FST15-168

9. **Visible emission spectroscopy of highly charged tungsten ions in LHD: I. Survey of new visible emission lines**
M Shinohara, **K Fujii**, D Kato, N Nakamura, M Goto, S Morita, M Hasuo, LHD Experiment Group2
Physica Scripta **90,** 125402 (2015)
10.1088/0031-8949/90/12/125402

10. **Visible emission spectroscopy of highly charged tungsten ions in LHD: II. Evaluation of tungsten ion temperature**
K Fujii, Y Takahashi, Y Nakai, D Kato, M Goto, S Morita, M Hasuo, LHD Experiment Group2
Physica Scripta **90,** 125403 (2015)
10.1088/0031-8949/90/12/125403

11. **Study of neutral hydrogen transport in LHD core plasmas based on high dynamic-range Balmer-α spectroscopy**
K. Fujii, M. Goto, S. Morita, The LHD Experiment Group
Nuclear Fusion **55,** 063029 (2015)
10.1088/0029-5515/55/6/063029

12. **Development of a high dynamic range spectroscopic system for observation of neutral hydrogen atom density distribution in Large Helical Device core plasma**
K. Fujii, S. Atsumi, S. Watanabe, T. Shikama, M. Goto, S. Morita, M. Hasuo
Review of Scientific Instruments **85,** 023502 (2014)
10.1063/1.4863650

13. **Hydrogen transport diagnostics by atomic and molecular emission line profiles simultaneously measured for large helical device**
K. Fujii, T. Shikama, M. Goto, S. Morita, M. Hasuo

Physics of Plasmas **20,** 012514 (2013)
10.1063/1.4789454

14. **A Collisional-Radiative Model for Hydrogen Atom Including Velocity Changing Collisions**
Keisuke FUJII, Taiichi SHIKAMA, Keiji SAWADA, Motoshi GOTO, Shigeru MORITA, Masahiro HASUO
Plasma and Fusion Research **6,** 2401125-2401125 (2011)
10.1585/pfr.6.2401125

15. **Kinetic energy measurement of hydrogen in LHD peripheral plasma with a multi-wavelength-range fine-resolution spectrometer**
Keisuke Fujii, Keisuke Mizushiri, Tomomi Nishioka, Taiichi Shikama, Atsushi Iwamae, Motoshi Goto, Shigeru Morita, Masahiro Hasuo
Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment **623,** 690-692 (2010)
10.1016/j.nima.2010.02.100

16. **Development of multiwavelength-range fine-resolution spectrometer for hydrogen emissions and its application to large helical device periphery plasmas**
K. Fujii, K. Mizushiri, T. Nishioka, T. Shikama, A. Iwamae, M. Goto, S. Morita, S Kado, K. Sawada, M. Hasuo
Review of Scientific Instruments **81,** 033106 (2010)
10.1063/1.3356730

List of published papers

17. **Comprehensive Laboratory Measurements Resolving the LMM Dielectronic Recombination Satellite Lines in Ne-like Fe xvii Ions**
Filipe Grilo, Chintan Shah, Steffen Kühn, René Steinbrügge, **Keisuke Fujii**, José Marques, Ming Feng Gu, José Paulo Santos, José R. Crespo López-Urrutia, Pedro Amaro
The Astrophysical Journal **913,** 140 (2021)
10.3847/1538-4357/abf737

18. **Ro-vibrational population distribution in the ground state of hydrogen isotopologues in LHD peripheral plasmas deduced from emission spectroscopy**
Hiroki Ishihara, Arseniy Kuzmin, Masahiro Kobayashi, Taiichi Shikama, Keiji Sawada, Seiki Saito, Hiroaki Nakamura, **Keisuke Fujii**, Masahiro Hasuo
Journal of Quantitative Spectroscopy and Radiative Transfer **267,** 107592 (2021)
10.1016/j.jqsrt.2021.107592

19. **Application of multiple regression for sensitivity analysis of helium line emissions to the electron density and temperature in Magnum-PSI**
Shin Kajita, Daisuke Nishijima, **Keisuke Fujii**, Gijs Akkermans, Hennie van der Meiden
Plasma Physics and Controlled Fusion **63,** 055018 (2021)
10.1088/1361-6587/abf36e

20. **On the triad transfer analysis of plasma turbulence: symmetrization, coarse graining, and directional representation**
S Maeyama, M Sasaki, **K Fujii**, T Kobayashi, R O Dendy, Y Kawachi, H Arakawa, S Inagaki
New Journal of Physics **23,** 043049 (2021)

10.1088/1367-2630/abeffc

21. **Compressing the time series of five dimensional distribution function data from gyrokinetic simulation using principal component analysis**
Yuuichi Asahi, **Keisuke Fujii**, Dennis Manuel Heim, Shinya Maeyama, Xavier Garbet, Virginie Grandgirard, Yanick Sarazin, Guilhem Dif-Pradalier, Yasuhiro Idomura, Masatoshi Yagi
Physics of Plasmas **28,** 012304 (2021)
10.1063/5.0023166

22. **Observation of strong two-electron–one-photon transitions in few-electron ions**
M. Togawa, S. Kühn, C. Shah, P. Amaro, R. Steinbrügge, J. Stierhof, N. Hell, M. Rosner, **K. Fujii**, M. Bissinger, R. Ballhausen, M. Hoesch, J. Seltmann, S. Park, F. Grilo, F. S. Porter, J. P. Santos, M. Chung, T. Stöhlker, J. Wilms, T. Pfeifer, G. V. Brown, M. A. Leutenegger, S. Bernitt, J. R. Crespo López-Urrutia
Physical Review A **102,** 052831 (2020)
10.1103/PhysRevA.102.052831

23. **Plasma Spectroscopy on an Aluminum-Pellet Ablation Cloud in an LHD Plasma with an Echelle Spectrometer**
Hirotaka Tanaka, **Keisuke Fujii**, Taiichi Shikama, Shigeru Morita, Motoshi Goto, Masahiro Hasuo
Atoms **8,** 81 (2020)
10.3390/atoms8040081

24. **High Resolution Photoexcitation Measurements Exacerbate the Long-Standing Fe XVII Oscillator Strength Problem**
Steffen Kühn, Chintan Shah, José R. Crespo López-Urrutia, **Keisuke Fujii**, René Steinbrügge, Jakob Stierhof, Moto Togawa, Zoltán Harman, Natalia S. Oreshkina, Charles Cheung, Mikhail G. Kozlov, Sergey G. Porsev, Marianna S. Safronova, Julian C. Berengut, Michael Rosner, Matthias Bissinger, Ralf Ballhausen, Natalie Hell, SungNam Park, Moses Chung, Moritz Hoesch, Jörn Seltmann, Andrey S. Surzhykov, Vladimir A. Yerokhin, Jörn Wilms, F. Scott Porter, Thomas Stöhlker, Christoph H. Keitel, Thomas Pfeifer, Gregory V. Brown, Maurice A. Leutenegger, Sven Bernitt
Physical Review Letters **124,** 225001 (2020)
10.1103/PhysRevLett.124.225001

25. **Emission spectroscopy of He lines in high-density plasmas in Magnum-PSI**
Shin Kajita, Gijs Akkermans, **Keisuke Fujii**, Hennie van der Meiden, M. C. M. van de Sanden
AIP Advances **10,** 025225 (2020)
10.1063/1.5143481

26. **Isotope Effect on Energy Confinement Time and Thermal Transport in Neutral-Beam-Heated Stellarator-Heliotron Plasmas**
H. Yamada, K. Tanaka, R. Seki, C. Suzuki, K. Ida, **K. Fujii**, M. Goto, S. Murakami, M. Osakabe, T. Tokuzawa, M. Yokoyama, M. Yoshinuma, LHD Experiment Group
Physical Review Letters **123,** 185001 (2019)
10.1103/PhysRevLett.123.185001

27. **Atomic kinetics calculations of complex highly-charged ions in plasmas in non-local thermodynamic equilibrium by using a Monte-Carlo approach**
Akira Sasaki, Richard M. More, **Keisuke Fujii**, Daiji Kato, Izumi Murakami
High Energy Density Physics **32,** 1-7 (2019)
10.1016/j.hedp.2019.04.005

28. **The isotope effect on impurities and bulk ion particle transport in the Large Helical Device**
K. Ida, R. Sakamoto, M. Yoshinuma, K. Yamazaki, T. Kobayashi, Y. Fujiwara, C. Suzuki, K. Fuji, J. Chen, I. Murakami, M. Emoto, R. Mackenbach, H. Yamada, G. Motojima, S. Masuzaki, K. Mukai, K. Nagaoka, H. Takahashi, T. Oishi, M. Goto, S. Morita, N. Tamura, H. Nakano, S. Kamio, R. Seki, M. Yokoyama, S. Murakami, M. Nunami, M. Nakata, T. Morisaki, M. Osakabe, the LHD Experiment Group
Nuclear Fusion **59,** 056029 (2019)
10.1088/1741-4326/ab0e41

29. **Spatially resolved laser absorption spectroscopy on a micro-hollow cathode He plasma**
Keisuke Ueno, Kenta Kamebuchi, Jiro Kakutani, Leo Matsuoka, Shinichi Namba, **Keisuke Fujii**, Taiichi Shikama, Masahiro Hasuo
Japanese Journal of Applied Physics **58,** SAAB03 (2019)
10.7567/1347-4065/aaec19

30. **Analysis of the impurity flow velocity in a wide plasma parameter range for deuterium and hydrogen plasmas in the divertor legs of the stochastic layer in LHD**
A. Kuzmin, M. Kobayashi, T. Nakano, G. Kawamura, M. Hasuo, **K. Fujii**, T. Morisaki
Nuclear Materials and Energy **17,** 217-221 (2018)
10.1016/j.nme.2018.11.009

31. **Laser absorption spectroscopy for measurement of He metastable atoms of a microhollow cathode plasma**
Keisuke Ueno, Kenta Kamebuchi, Jiro Kakutani, Leo Matsuoka, Shinichi Namba, **Keisuke Fujii**, Taiichi Shikama, Masahiro Hasuo
Japanese Journal of Applied Physics **57,** 01AA03 (2018)
10.7567/jjap.57.01aa03

32. **Measurements of the Impurity Flow Velocity and Temperature in Deuterium and Hydrogen Plasmas in the Divertor Legs of the Stochastic Layer in LHD**
Arseniy KUZMIN, Masahiro KOBAYASHI, Tomohide NAKANO, Masahiro HASUO, **Keisuke FUJII**, Motoshi GOTO, Taiichi SHIKAMA, Tomohiro MORISAKI, the LHD Experiment Group
Plasma and Fusion Research **13,** 3402058-3402058 (2018)
10.1585/pfr.13.3402058

33. **Spatially Resolved Measurements of Metastable Atom Density and Electric Field Strength in a Microhollow Cathode Helium Plasma by Laser Absorption Spectroscopy**
Keisuke UENO, Kenta KAMEBUCHI, Jiro KAKUTANI, Leo MATSUOKA, Shinichi NAMBA, **Keisuke FUJII**, Taiichi SHIKAMA, Masahiro HASUO
Plasma and Fusion Research **13,** 3406070-3406070 (2018)
10.1585/pfr.13.3406070

34. **Extension of the operational regime of the LHD towards a deuterium experiment**
Y. Takeiri, T. Morisaki, M. Osakabe, M. Yokoyama, S. Sakakibara, H. Takahashi, Y. Nakamura, T. Oishi, G. Motojima, S. Murakami, K. Ito, A. Ejiri, S. Imagawa, S. Inagaki, M. Isobe, S. Kubo, S. Masamune, T. Mito, I. Murakami, K. Nagaoka, K. Nagasaki, K. Nishimura, M. Sakamoto, R. Sakamoto, T. Shimozuma, K. Shinohara, H. Sugama, K.Y. Watanabe, J.W. Ahn, N. Akata, T. Akiyama, N. Ashikawa, J. Baldzuhn, T. Bando, E. Bernard, F. Castejón, H. Chikaraishi, M. Emoto, T. Evans, N. Ezumi, **K. Fujii**, H. Funaba, M. Goto, T. Goto, D. Gradic, Y. Gunsu, S. Hamaguchi, H. Hasegawa, Y. Hayashi, C. Hidalgo, T. Higashiguchi, Y. Hirooka, Y. Hishinuma, R. Horiuchi, K. Ichiguchi, K. Ida, T. Ido, H. Igami, K. Ikeda, S. Ishiguro, R. Ishizaki, A. Ishizawa, A. Ito, Y. Ito, A. Iwamoto, S. Kamio, K. Kamiya, O. Kaneko, R. Kanno, H. Kasahara, D. Kato, T. Kato, K.

Kawahata, G. Kawamura, M. Kisaki, S. Kitajima, W.H. Ko, M. Kobayashi, S. Kobayashi, T. Kobayashi, K. Koga, A. Kohyama, R. Kumazawa, J.H. Lee, D. López-Bruna, R. Makino, S. Masuzaki, Y. Matsumoto, H. Matsuura, O. Mitarai, H. Miura, J. Miyazawa, N. Mizuguchi, C. Moon, S. Morita, T. Moritaka, K. Mukai, T. Muroga, S. Muto, T. Mutoh, T. Nagasaka, Y. Nagayama, N. Nakajima, Y. Nakamura, H. Nakanishi, H. Nakano, M. Nakata, Y. Narushima, D. Nishijima, A. Nishimura, S. Nishimura, T. Nishitani, M. Nishiura, Y. Nobuta, H. Noto, M. Nunami, T. Obana, K. Ogawa, S. Ohdachi, M. Ohno, N. Ohno, H. Ohtani, M. Okamoto, Y. Oya, T. Ozaki, B.J. Peterson, M. Preynas, S. Sagara, K. Saito, H. Sakaue, A. Sanpei, S. Satake, M. Sato, T. Saze, O. Schmitz, R. Seki, T. Seki, I. Sharov, A. Shimizu, M. Shiratani, M. Shoji, C. Skinner, R. Soga, T. Stange, C. Suzuki, Y. Suzuki, S. Takada, K. Takahata, A. Takayama, S. Takayama, Y. Takemura, Y. Takeuchi, H. Tamura, N. Tamura, H. Tanaka, K. Tanaka, M. Tanaka, T. Tanaka, Y. Tanaka, S. Toda, Y. Todo, K. Toi, M. Toida, M. Tokitani, T. Tokuzawa, H. Tsuchiya, T. Tsujimura, K. Tsumori, S. Usami, J.L. Velasco, H. Wang, T.-H. Watanabe, T. Watanabe, J. Yagi, M. Yajima, H. Yamada, I. Yamada, O. Yamagishi, N. Yamaguchi, Y. Yamamoto, N. Yanagi, R. Yasuhara, E. Yatsuka, N. Yoshida, M. Yoshinuma, S. Yoshimura, Y. Yoshimura
Nuclear Fusion **57,** 102023 (2017)
10.1088/1741-4326/aa7fc2

35. **Behavior of 23S metastable state He atoms in low-temperature recombining plasmas**
Shin Kajita, Tadashi Tsujihara, Mitsutoshi Aramaki, Hennie van der Meiden, Hiroshi Oshima, Noriyasu Ohno, Hirohiko Tanaka, Ryo Yasuhara, Tsuyoshi Akiyama, **Keisuke Fujii**, Taiichi Shikama
Physics of Plasmas **24,** 073301 (2017)
10.1063/1.4990077

36. **Comparison of Ion Internal Transport Barrier Formation between Hydrogen and Helium Dominated Plasmas**
Kenichi NAGAOKA, Hiromi TAKAHASHI, Kenji TANAKA, Masaki OSAKABE, Sadayoshi MURAKAMI, Shogo MAETA, Masayuki YOKOYAMA, **Keisuke FUJII**, Haruhisa NAKANO, Hiroshi YAMADA, Yasuhiko TAKEIRI, Katsumi IDA, Mikiro YOSHINUMA, the LHD Experiment Group
Plasma and Fusion Research **11,** 2402106-2402106 (2016)
10.1585/pfr.11.2402106

37. **Integrated discharge scenario for high-temperature helical plasma in LHD**
K. Nagaoka, H. Takahashi, S. Murakami, H. Nakano, Y. Takeiri, H. Tsuchiya, M. Osakabe, K. Ida, M. Yokoyama, M. Yoshinuma, S. Morita, M. Goto, T. Oishi, N. Pablant, **K. Fujii**, K. Tanaka, N. Tamura, Y. Nakamura, X. Du, T. Ido, A. Shimizu, S. Kubo, H. Igami, R. Seki, C. Suzuki, Y. Suzuki, K. Tsumori, K. Ikeda, M. Kisaki, Y. Yoshimura, T. Shimozuma, T. Seki, K. Saito, H. Kasahara, S. Kamio, T. Mutoh, O. Kaneko, H. Yamada, A. Komori
Nuclear Fusion **55,** 113020 (2015)
10.1088/0029-5515/55/11/113020

38. **Overview of transport and MHD stability study: focusing on the impact of magnetic field topology in the Large Helical Device**
K. Ida, K. Nagaoka, S. Inagaki, H. Kasahara, T. Evans, M. Yoshinuma, K. Kamiya, S. Ohdach, M. Osakabe, M. Kobayashi, S. Sudo, K. Itoh, T. Akiyama, M. Emoto, A. Dinklage, X. Du, **K. Fujii**, M. Goto, T. Goto, M. Hasuo, C. Hidalgo, K. Ichiguchi, A. Ishizawa, M. Jakubowski, G. Kawamura, D. Kato, S. Morita, K. Mukai, I. Murakami, S. Murakami, Y. Narushima, M. Nunami, N. Ohno, N. Pablant, S. Sakakibara, T. Seki, T. Shimozuma, M. Shoji, K. Tanaka, T. Tokuzawa, Y. Todo, H. Wang, M. Yokoyama, H. Yamada, Y. Takeiri, T. Mutoh, S. Imagawa, T. Mito, Y. Nagayama, K.Y. Watanabe, N. Ashikawa, H. Chikaraishi, A. Ejiri, M. Furukawa, T. Fujita, S. Hamaguchi, H. Igami, M. Isobe, S. Masuzaki, T. Morisaki, G. Motojima, K. Nagasaki, H. Nakano, Y. Oya, C. Suzuki, Y. Suzuki, R. Sakamoto, M. Sakamoto, A. Sanpei, H. Takahashi, H. Tsuchiya,

M. Tokitani, Y. Ueda, Y. Yoshimura, S. Yamamoto, K. Nishimura, H. Sugama, T. Yamamoto, H. Idei, A. Isayama, S. Kitajima, S. Masamune, K. Shinohara, P.S. Bawankar, E. Bernard, M. von Berkel, H. Funaba, X.L. Huang, T. Ii, T. Ido, K. Ikeda, S. Kamio, R. Kumazawa, T. Kobayashi, C. Moon, S. Muto, J. Miyazawa, T. Ming, Y. Nakamura, S. Nishimura, K. Ogawa, T. Ozaki, T. Oishi, M. Ohno, S. Pandya, A. Shimizu, R. Seki, R. Sano, K. Saito, H. Sakaue, Y. Takemura, K. Tsumori, N. Tamura, H. Tanaka, K. Toi, B. Wieland, I. Yamada, R. Yasuhara, H. Zhang, O. Kaneko, A. Komori, Collaborators
Nuclear Fusion **55,** 104018 (2015)
10.1088/0029-5515/55/10/104018

39. **Effect of the RF wall conditioning on the high performance plasmas in the Large Helical Device**
H. Takahashi, M. Osakabe, K. Nagaoka, H. Nakano, M. Tokitani, **K. Fujii**, S. Murakami, Y. Takeiri, T. Seki, K. Saito, H. Kasahara, R. Seki, S. Kamio, S. Masuzaki, T. Mutoh
Journal of Nuclear Materials **463,** 1100-1103 (2015)
10.1016/j.jnucmat.2014.11.131

40. **Flow damping due to stochastization of the magnetic field**
K. Ida, the LHD Experiment Group, M. Yoshinuma, H. Tsuchiya, T. Kobayashi, C. Suzuki, M. Yokoyama, A. Shimizu, K. Nagaoka, S. Inagaki, K. Itoh
Nature Communications **6,** 5816 (2015)
10.1038/ncomms6816

41. **Development of the Heating Scenarios to Achieve High-Ion Temperature Plasma in the Large Helical Device**
Yasuhiko TAKEIRI, Osamu KANEKO, Masaki OSAKABE, Kenichi NAGAOKA, Sadayoshi MURAKAMI, Hiromi TAKAHASHI, Haruhisa NAKANO, Katsumi IDA, Shigeru MORITA, Masayuki YOKOYAMA, Mikiro YOSHINUMA, **Keisuke FUJII**, Motoshi GOTO, Chihiro SUZUKI, Ryosuke SEKI, Katsuyoshi TSUMORI, Katsunori IKEDA, Masashi KISAKI, Takashi MUTOH, Hiroshi YAMADA, Akio KOMORI, the LHD Experiment Group
Plasma and Fusion Research **10,** 1402001-1402001 (2015)
10.1585/pfr.10.1402001

42. **Extension of operation regimes and investigation of three-dimensional currentless plasmas in the Large Helical Device**
O. Kaneko, H. Yamada, S. Inagaki, M. Jakubowski, S. Kajita, S. Kitajima, Kobayashi, K. Koga, T. Morisaki, S. Morita, T. Mutoh, S. Sakakibara, Y. Suzuki, H. Takahashi, K. Tanaka, K. Toi, Y. Yoshimura, T. Akiyama, Y. Asahi, N. Ashikawa, H. Chikaraishi, A. Cooper, D.S. Darrow, E. Drapiko, P. Drewelow, X. Du, A. Ejiri, M. Emoto, T. Evans, N. Ezumi, **K. Fujii**, T. Fukuda, H. Funaba, M. Furukawa, D.A. Gates, M. Goto, T. Goto, W. Guttenfelder, S. Hamaguchi, M. Hasuo, T. Hino, Y. Hirooka, K. Ichiguchi, K. Ida, H. Idei, T. Ido, H. Igami, K. Ikeda, S. Imagawa, T. Imai, M. Isobe, M. Itagaki, T. Ito, K. Itoh, S. Itoh, A. Iwamoto, K. Kamiya, T. Kariya, H. Kasahara, N. Kasuya, D. Kato, T. Kato, K. Kawahata, F. Koike, S. Kubo, R. Kumazawa, D. Kuwahara, S. Lazerson, H. Lee, S. Masuzaki, S. Matsuoka, H. Matsuura, A. Matsuyama, C. Michael, D. Mikkelsen, O. Mitarai, T. Mito, J. Miyazawa, G. Motojima, K. Mukai, A. Murakami, I. Murakami, S. Murakami, T. Muroga, S. Muto, K. Nagaoka, K. Nagasaki, Y. Nagayama, N. Nakajima, H. Nakamura, Y. Nakamura, H. Nakanishi, H. Nakano, T. Nakano, K. Narihara, Y. Narushima, K. Nishimura, S. Nishimura, M. Nishiura, Y.M. Nunami, T. Obana, K. Ogawa, S. Ohdachi, N. Ohno, N. Ohyabu, T. Oishi, M. Okamoto, A. Okamoto, M. Osakabe, Y. Oya, T. Ozaki, N. Pablant, B.J. Peterson, A. Sagara, K. Saito, R. Sakamoto, H. Sakaue, M. Sasao, K. Sato, M. Sato, K. Sawada, R. Seki, T. Seki, V. Sergeev, S. Sharapov, I. Sharov, A. Shimizu, T. Shimozuma, M. Shiratani, M. Shoji, S. Sudo, H. Sugama, C. Suzuki, K. Takahata, Y. Takeiri, Y. Takemura, M. Takeuchi, H. Tamura, N. Tamura, H. Tanaka, T. Tanaka, M. Tingfeng, Y. Todo, M. Tokitani, K. Tokunaga, T. Tokuzawa, H. Tsuchiya,

K. Tsumori, Y. Ueda, L. Vyacheslavov, K.Y. Watanabe, T. Watanabe, T.H. Watanabe, B. Wieland, I. Yamada, S. Yamada, S. Yamamoto, N. Yanagi, R. Yasuhara, M. Yokoyama, N. Yoshida, S. Yoshimura, T. Yoshinaga, M. Yoshinuma, A. Komori
Nuclear Fusion **53,** 104015 (2013)
10.1088/0029-5515/53/10/104015

43. **Effective screening of iron impurities in the ergodic layer of the Large Helical Device with a metallic first wall**
S. Morita, C.F. Dong, M. Kobayashi, M. Goto, X.L. Huang, I. Murakami, T. Oishi, E.H. Wang, N. Ashikawa, **K. Fujii**, M. Hasuo, H. Kasahara, D. Kato, F. Koike, S. Masuzaki, H.A. Sakaue, T. Shikama, N. Yamaguchi, the LHD Experiment Group
Nuclear Fusion **53,** 093017 (2013)
10.1088/0029-5515/53/9/093017

44. **Development of a compact thermal lithium atom beam source for measurements of electron velocity distribution function anisotropy in electron cyclotron resonance plasmas**
T. Nishioka, T. Shikama, S. Nagamizo, **K. Fujii**, H. Zushi, M. Uchida, A. Iwamae, H. Tanaka, T. Maekawa, M. Hasuo
Review of Scientific Instruments **84,** 073509 (2013)
10.1063/1.4815721

45. **Evaluation of particle source rate and its influence on particle transport in fusion plasma**
M Goto, K Sawada, **K Fujii**, M Hasuo, S Morita
Journal of Physics: Conference Series **397,** 012023 (2012)
10.1088/1742-6596/397/1/012023

46. **Wideband High-Resolution Spectroscopy on Al-pellet Ablation Plasmas in Large Helical Device**
M Hasuo, **K Fujii**, T Shikama, S Morita, M Goto, H Tanaka
Journal of Physics: Conference Series **397,** 012016 (2012)
10.1088/1742-6596/397/1/012016

47. **A simultaneous measurement of polarization-resolved spectra of neutral helium 23P–33D, 21P–31D and 23P–33S emissions from the periphery of a Large Helical Device plasma**
K Mizushiri, **K Fujii**, T Shikama, A Iwamae, M Goto, S Morita, M Hasuo
Plasma Physics and Controlled Fusion **53,** 105012 (2011)
10.1088/0741-3335/53/10/105012

48. **Plasma polarization spectroscopy of atomic and molecular emissions from magnetically confined plasmas1This review is part of a Special Issue on the 10th International Colloquium on Atomic Spectra and Oscillator Strengths for Astrophysical and Laboratory Plasmas.**
T. Shikama, **K. Fujii**, S. Kado, H. Zushi, M. Sakamoto, A. Iwamae, M. Goto, S. Morita, M. Hasuo
Canadian Journal of Physics **89,** 495-501 (2011)
10.1139/p10-118

49. **Evaluation of hydrogen atom density in the plasma core region based on the Balmer-α line profile**
M. Goto, K. Sawada, **K. Fujii**, M. Hasuo, S. Morita
Nuclear Fusion **51,** 023005 (2011)
10.1088/0029-5515/51/2/023005

50. **Calculation of a magnetic field effect on emission spectra of light diatomic molecules for diagnostic application to fusion edge plasmas**

T Shikama, **K Fujii**, K Mizushiri, M Hasuo, S Kado, H Zushi
Plasma Physics and Controlled Fusion **51,** 122001 (2009)
10.1088/0741-3335/51/12/122001

51. **Edge and Core Impurity Transport Study with Spectroscopic Instruments in LHD**
Shigeru Morita, Motoshi Goto, Masahiro Kobayashi, Sadatsugu Muto, Malay Bikas Chowdhuri, Dong Chunfeng, Zhou Hangyu, Cui Zhengying, **Keisuke Fujii**, Akihiro Furuzawa, Masahiro Hasuo, Atsushi Iwamae, Jie Yinxian, Mohammed Koubiti, Ikuya Sakurai, Yuzuru Tawara, Wan Baonian, Wu Zhenwei, Naohiro Yamaguchi
Plasma Science and Technology **11,** 402-408 (2009)
10.1088/1009-0630/11/4/07

52. **Gene transfer device utilizing micron-spiked electrodes produced by the self-organization phenomenon of Fe-alloy**
Naoki Miyano, Yuuki Inoue, Yuji Teramura, **Keisuke Fujii**, Fujio Tsumori, Hiroo Iwata, Hidetoshi Kotera
Lab on a Chip **8,** 1104 (2008)
10.1039/b718655j

Unpublished papers

53. **Power-law Velocity Distribution of Light Radicals in Low-Temperature Plasmas**
Keisuke Fujii, Jun Imano, Arseniy Kuzmin, Taiichi Shikama, Masahiro Hasuo
Under review in Physical Review Letters
https://arxiv.org/abs/2103.04463

List of Talks

Invited talks

1. **Power-Law Distribution of Emission Lines from Many-Electron Atoms**
21st International Conference on Atomic Processes in Plasmas
Vienna, Austria, planned in 12-16 April 2021, but postponed

2. **Bayesian Inference for the LHD Experiment Data**
IAEA Technical Meeting on Uncertainty Assessment and Benchmark Experiments for Atomic and Molecular Data for Fusion Applications
Vienna, Austria, 2016. Dec.19-Dec.21

3. **Neutral Hydrogen Dynamics in Fusion Core Plasmas Revealed by High Dynamic Range Balmer-α Spectroscopy**
9th International Conference on Atomic and Molecular Data and Their Applications
Jena, Germany, 2014. Sep.21-Sep.25

Oral talks

1. **Power-Law Distribution of Line Intensity in Complex Many-Electron Atoms**
APS Division of Atomic Molecular and Optical Physics
Online, United States, 2021. May.31-Jun.04

2. **Electron Density Estimation from Multichannel Laser Interferometer Measurement in LHD with Systematic Bias Compensation**

3rd IAEA Technical Meeting on Fusion Data Processing Validation and Analysis
Vienna, Austria, 2019. May.28-May.31

3. **Statistical completion and validation of the NIST Atomic Spectral Database**
DPG annual conference (Rostock 2019)
Rostock, Germany, 2019. Mar.11-Mar.15

4. **Experimental evaluation of fractional abundance data for W23+ - W28+**
The 7 th China-Japan-Korea Joint Seminar on Atomic and Molecular Processes in Plasma (AMPP2018)
Hefei, China, 2018. Jun.24-Jun.26

5. **Automatic Fusion Plasma Data Analysis based on Bayesian Statistics**
1st International Conference on Data-Driven Plasma Science
York, UK, 2018. Jun.11-Jun.13

6. **Machine Learning of Noise in LHD Thomson Scattering System**
2nd IAEA Technical Meeting on the Fusion Data Processing; Validation and Analysis
Boston, USA, 2017. May.30-Jun.02

7. **Measurement of the neutral hydrogen atom density in the LHD core plasmas based on the spectral inversion**
1st IAEA Technical Meeting on Fusion Data Processing; Validation and Analysis
Nice, France, 2015. Jun.01-Jun.03

8. **Hydrogen atomic and molecular emission locations and intensities in the LHD edge plasma determined from simultaneously observed polarization spectra**
24th International Toki Conference (ITC-24)
Toki, Japan, 2014. Nov.04-Nov.07

Posters

1. **Statistical Completion and Validation of Atomic Energy Level Database Based on Low Rank Nature of Isoelectronic Sequence**
2nd International Conference on Data-Driven Plasma Science
Marseille, France, 2019. May.13-May.17

2. **Automatic Robust Regression Analysis of Fusion Plasma Experiment Data based on Generative Modelling**
45th Conference on Plasma Physics (EPS 2018)
Prague, the Czech Republic, 2018. Jun.02-Jun.06

3. **Study of Neutral Hydrogen Transport in LHD Core Plasmas Based on High Dynamic-Range Balmer-Alpha Spectroscopy**
25th IAEA Fusion Energy Conference
St. Petersburg, Russian Ferderation, 2014. Oct.13-Oct.18

4. **Electron Density Dependence of the Neutral Hydrogen Atom Transport in LHD Core Plasmas Studied by Balmer-α Spectroscopy**
9th Asia Plasma Fusion and Fusion Association Conference
Gyeongju City, Korea, 2013. Nov.05-Nov.08

5. **Comparison of Balmer-α and -β Line Intensities and Shapes with a Monte-Carlo Neutral Transport Calculation of Large Helical Device**
   20th International Conference on Spectral Line Shapes
   Newfoundland, Canada, 2010. Jun.06-Jun.11

6. **Kinetic Energy Measurement of Hydrogen in LHD Peripheral Plasma with a Multi-wavelength-range Fine-resolution Spectrometer**
   1st International Conference on Frontiers in Diagnostic
   Frascati, Italy, 2009. Nov.24-Nov.27

7. **Development of a Multi-wavelength-range High-resolution Spectrometer for Hydrogen Emissions and its Application to the LHD Edge Plasma**
   16th International Conference on Atomic Processes in Plasmas
   Monteley, USA, 2009. Mar.22-Mar.26

8. **Spectroscopic Diagnostics of helium discharge produced during sucrose triboluminescence**
   14th International Congress on Plasma Physics (ICPP)
   Fukuoka, Japan, 2008. Sep.08-Sep.12

List of Grants Won

- **Development of Atomic Data Infrastructure with Machine Learning**
  Japan Society for the Promotion of Science (Tokyo)
  2019-2022, *GRANT_NUMBER: 19K14680*
  3,640,000 JPY

- データ解析技術の高度化による非線形複雑システムの潜在構造抽出と可視化 (Latent Structure Extraction and Visualization by Advancing Data Analysis Methods)
  National Institutes of Natural Sciences (Tokyo)
  2019-2020, *GRANT_NUMBER: Joint Research 01111905*
  2,340,000 JPY

- 時系列高次元データからの潜在ダイナミクスの抽出と可視化 (Latent Dynamics Extraction and Visualization from High-Dimensional Temporal Data)
  National Institutes of Natural Sciences (Tokyo)
  2017-2018, *GRANT_NUMBER: Joint Research*
  4,000,000 JPY

- データセントリックプラズマ物理研究の開拓 (Pioneering Data-Centric Plasma Physics)
  National Institutes of Natural Sciences (Tokyo)
  2017-2018, *GRANT_NUMBER: Joint-Workshop*
  900,000 JPY

- データ駆動型キャリブレーションの実現による科学計測システムの超高精度化 (Development of Data-Driven Calibration for Ultra Accurate Scientific Instruments)
  Yazaki Memorial Foundation for Science and Technology (Tokyo)
  2016-2017, *GRANT_NUMBER: 075550*
  950,000 JPY

- **Measurement of ion temperature spatial structure in high temperature plasmas based on Balmer-**

alpha spectrum
Japan Society for the Promotion of Science (Tokyo)
2014-2017, *GRANT_NUMBER: 26610191*
3,900,000 JPY

- **Development of ultra-high dynamic rage spectroscopic method for evaluation of neutral hydrogen density distribution in fusion core plasmas**
  Japan Society for the Promotion of Science (Tokyo)
  2012-2014, *GRANT_NUMBER: 24860037*