TO: Executive Secretaries of the US-Japan Fusion Research Collaboration

FROM: Steering Committee, US-Japan Joint Institute for Fusion Theory (JIFT)

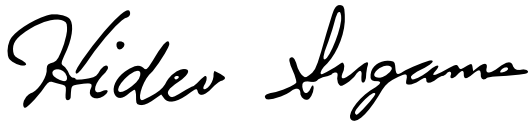
DATE: March 1, 2024

SUBJECT: JIFT Annual Report of Activities for 2023-2024

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Annual Report of JIFT Activities





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Annual Report of Activities

US-Japan Joint Institute for Fusion Theory

April 1, 2023–March 31, 2024

JIFT Steering Committee

Co-Chairmen: H. Sugama and F. L. Waelbroeck

Co-Executive Secretaries: Y. Todo and A. Arefiev

March 1, 2024

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1. *INTRODUCTION*

The Joint Institute for Fusion Theory (JIFT) is one of the four programs through which the US-Japan Fusion Research Collaboration is organized. The other three programs are the Fusion Physics Planning Committee (FPPC), the Fusion Technology Planning Committee (FTPC), and the US-Japan Joint Project (FRONTIER).

The distinctive objectives of the JIFT program are (1) to advance the theoretical understanding of plasmas, with special emphasis on stability, equilibrium, heating, and transport in magnetic fusion systems; and (2) to develop fundamental theoretical and computational tools and concepts for understanding nonlinear plasma phenomena. Both objectives are pursued through collaborations between U.S. and Japanese scientists by means of two types of exchange program activities—namely, workshops and exchange visitors.

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Each year the JIFT program usually consists of four topical workshops (two in each country), six exchange scientists (three from each country). So far, during its 43 years of successful operation, JIFT has sponsored 250 long-term visits by exchange scientists and 142 topical workshops.

- The *workshops* typically have an attendance of 15–30 participants, of whom usually three to seven scientists (depending on the particular workshop) travel to the workshop from the non-host country. Scientists from countries other than the U.S. and Japan are also often invited to participate in JIFT workshops, either as observers or multi-laterals.
- Of the approximately three *exchange visitors* in each direction every year, one (called the "JIFT Visiting Professor") is supported by the host country, while the others (called "Exchange Scientists") are supported by the sending country. The visits of the Exchange Scientists usually last from one to several weeks in duration, whereas the Visiting Professors normally stay for one month.

The topics and also the participating scientists for the JIFT exchange visits, and workshops are selected so as to have a balanced representation of critical issues in magnetic fusion research, including both fundamental problems as well as questions of near-term significance, and also to take into account the specific capabilities and interests of both countries. The Japanese and US members of the JIFT Steering Committee agree together on the appropriateness of proposed topics before recommending them.

2. *SUMMARY OF COMPLETED ACTIVITIES (2023-2024 PROGRAM)*

Some of the activities in personal exchanges—that had been scheduled for the 2023-2024 JIFT program were done in remote collaborations because of the COVID-19. The JIFT Steering Committee meeting was held by email for discussing schedules for the 2023-2024 and 2024-2025 JIFT programs.

Summary reports about JIFT activities for 2023-2024 are given below.

A 2023-2024 Workshops

US to Japan:

JF-3 Theory and simulation on the high field and high energy density physics
Organizers: Yasuhiko Sentoku (ILE, Osaka U.) and Alexey Arefiev (UCSD)
Location: Pacifico Yokohama, Kanagawa Pref., Japan
Dates: April 17-17, 2023
Summary:

The purpose of the workshop was to discuss research on theory and simulation of high field and high energy density physics. There were 12 participants (9 from Japan, 2 from the U.S., and 1 from France). Presentations were given on high magnetic fields with intense laser lights, electron and positron production in strong fields, MeV ion acceleration, and burning physics in laser fusion, based on major NIF results reported by LLNL participants and updates on the ELI-NP laser system,

fast ignition in laser fusion scheme and how to proceed with pair production research in international cooperation were discussed.

JF-4 Progress of fusion research with extreme-scale computing and data science
Organizers: Toseo Moritaka (NIFS) and C-S. Chang (PPPL)
Location: National Institute for Fusion Science, Gifu, Japan
Dates: November 20-21, 2023
Summary:

The purpose of this workshop was to promote US-Japan collaborations on the co-design of fusion applications with extreme-scale computing and cutting-edge data science. This was the seventh in the series of JIFT workshops on exascale computing. There were 23 oral presentations (12 from the US, 11 from Japan), including 6 remote presentations. These presentations covered the latest progress in large-scale plasma simulations, machine learning, quantum computing, and cutting-edge computer facilities. The agenda and attendees can be obtained from the workshop website (https://workshop.nifs.ac.jp/exascale2023/).

B. 2023-2024 Exchange Visits

Japan to US:

JF-1 Collaboration on Tokamak boundary plasma turbulence simulations for divertor heat flux width
Visiting Scientist: Haruki SETO (QST)
Location: Lawrence Livermore National Laboratory, Livermore, CA, USA
Dates: Aug 7-16, 2023 including isolation due to COVID19 (Aug. 9-14)
Summary:

The purpose of this collaboration is to improve the numerical treatment of BOUT++ code [1] used for study on the extrapolation of the experimental scaling law of the divertor heat flux width [2,3] to the ITER-class device [4], which has been conducted at LLNL, by introducing a numerical scheme developed at QST to treat the interaction between turbulent and zonal flows [5]. A reliable prediction of divetor heat loads in ITER-class devices is important for the design and lifetime prediction of divertors in ITER and Japanese DEMO. Both parties will benefit from this collaboration, since QST can get the six-field reduced Braginskii module [6,7] developed at LLNL and LLNL can also get the extension to handle the interaction between turbulence and zonal flows developed at QST. In this collaboration, we have two personnel exchanges, one is JF-15 (Japan to US) and the other is JF-8 (US to Japan). Here, JF-15 is mainly focused on the possibility of research collaborations conducted mainly in QST. In FY2023 Dr. Seto visited to LLNL for 5 days, Aug 7-16, 2023 including isolation due to COVID19 Aug. 9-14. In the short visit, we had a research seminar. Dr. Seto presented recent research of two-stage crash process in ELM crash triggered by resistive drift ballooning mode [8]. After isolation due to COVID19, we implemented QST's BOUT++ code on a new LLNL's HPC Perlmutter. Dr Xu provided input files used in ITER divertor heat load predictions [4] to Dr Seto. We also discussed the possible impact of interplay between zonal flow and turbulence on the SOL heat flux width broadening in small ELMs in ITER, which is expected to be studied mainly by QST through JIFT collaboration after FY2024.

[1] B.D. Dudson et al., Comput Phys. Commun. 180 (2009) 1467.
[2] T. Eich et al., Nucl. Fusion 53 (2013) 093031.
[3] T. Eich et al., Nucl. Fusion 60 (2020) 056016.
[4] X.Q. Xu et al., Nucl. Fusion 59 (2019) 126039.
[5] H. Seto et al., Phys. Plasmas 26 (2019) 052507.
[6] T.Y. Xia et al., Nucl. Fusion 53 (2013) 073009.
[7] B. Zhu et al., Comput. Phys. Commun. 267 (2021) 108079.
[8] H. Seto et al., Submitted to Phys. Plasmas.

JF-2 Neutron transport in fast ignition laser fusion fuel
Visiting Scientist: Tomoyuki JOHZAKI (Hiroshima University)
Location: CMUXE, Purdue University, West Lafayette, Indiana (US)
Dates: Mar. 2-15, 2024
This exchange visit was canceled.

US to Japan:

JF-5 Collaboration on Tokamak boundary plasma turbulence simulations for divertor heat flux width
Visiting Scientist: Xue-Qiao Xu and Nami Li (LLNL)
Location: National Institutes for Quantum Science and Technology (QST), Rokkasho, Japan
Dates: Nov. 20-25, 2023, including Japan's National Holiday (Nov. 23)
Summary:
The purpose of this collaboration is to improve the numerical treatment of BOUT++ code [1] used for study on the extrapolation of the experimental scaling law of the divertor heat flux width [2,3] to the ITER-class device [4], which has been conducted at LLNL, by introducing a numerical scheme developed at QST to treat the interaction between turbulent and zonal flows [5]. A reliable prediction of divetor heat loads in ITER-class devices is important for the design and lifetime prediction of divertors in ITER and Japanese DEMO. Both parties will benefit from this collaboration, since QST can get the six-field reduced Braginskii module [6,7] developed at LLNL and LLNL can also get the extension to handle the interaction between turbulence and zonal flows developed at QST. In this collaboration, we have two personnel exchanges, one is JF-15 (Japan to US) and the other is JF-8 (US to Japan). Here, JF-8 is mainly focused on the possibility of research collaborations conducted mainly in LLNL. In FY2023 Drs. Xu and Li visited to QST Rokkasho for 4days (Nov. 20th -25th including one national holiday Nov. 23rd) . In the short visit, we had a research seminar. Dr. Xu presented a review of recent BOUT++ simulation works on small/grassy ELMs, SOL width broadening, plasma detachment and an introduction of a new SciDAC project ABOUND for integrated boundary plasma simulations. Dr. Li presented a talk on SOL width expansion driven by fluctuation energy intensity flux in small ELM regime. We also discussed on porting QST's BOUT++ to Perlmutter HPC partially done by JF-15. QST provided preliminary nonlinear simulation results using a single null diverted geometry of EAST device and their input files. Dr. LI confirmed that these input files were available for QST's BOUT++ on Perlmutter HPC. We also discussed the possible impact of interplay between zonal flow and turbulence on the SOL heat flux width broadening in small ELMs in EAST, which is expected to be studied mainly by LLNL through JIFT collaboration after FY2024.
[1] B.D. Dudson et al., Comput Phys. Commun. 180 (2009) 1467.
[2] T. Eich et al., Nucl. Fusion 53 (2013) 093031.
[3] T. Eich et al., Nucl. Fusion 60 (2020) 056016.
[4] X.Q. Xu et al., Nucl. Fusion 59 (2019) 126039.
[5] H. Seto et al., Phys. Plasmas 26 (2019) 052507.
[6] T.Y. Xia et al., Nucl. Fusion 53 (2013) 073009.
[7] B. Zhu et al., Comput. Phys. Commun. 267 (2021) 108079.

3. *PROGRAM ADMINISTRATION*

JIFT has a Steering Committee consisting of eight members, four from each country. Two of these members are the Japanese and US co-chairmen. Two other members of the Steering Committee, the US and Japanese co-executive secretaries, are responsible for the ongoing daily oversight of the progress of JIFT activities. The co-chairman and co-executive secretary on the US side are, respectively, the director and a research scientist at the Institute for Fusion Studies (IFS) of The University of Texas at Austin. The Japanese co-chairman is the

Leader of the Numerical Simulation Reactor Research Project at the National Institute for Fusion Science, and the Japanese co-executive secretary is the director of the Fundamental Physics Simulation Research Division in the Department of Helical Plasma Research at the National Institute for Fusion Science. Furthermore, on the Japanese side there is an Advisory Committee comprised of five members representing a spectrum of Japanese universities and the National Institutes for Quantum and Radiological Science and Technology; and on the US side there is an Advisory Committee comprised of five members representing a spectrum of US universities and national laboratories. The names of the persons on the Steering Committee and the names of the Advisors are listed below.

JIFT Steering Committee

US Members	*Japanese Members*
F. Waelbroeck (IFS)—Co-Chairman	H. Sugama (NIFS)—Co-Chairman
A. Arefiev (UCSD)—Co-Exec. Secretary	Y. Todo (NIFS)—Co-Exec. Secretary
D. Spong (ORNL)	S. Murakami (Kyoto)
J. Mandrekas (DOE)	Y. Sentoku (Osaka)

JIFT Advisors

Japanese Advisory Committee: Y. Kishimoto (Kyoto), T.-H. Watanabe (Nagoya), M. Yagi (QST)

*US Advisory Committee***:** J. Palastro (LLE/Univ. of Rochester), F. Graziani (LLNL), C. S. Chang (PPPL), and P. Terry (UWM)

The JIFT Steering Committee attempts to schedule workshops in such a way as to dovetail with other meetings. It also encourages participation at workshops by interested experimentalists and invites relevant available scientists from other countries to attend workshops.

As the principal program for fundamental theoretical exchanges in the US-Japan Fusion Research Collaboration, JIFT operates alongside the Fusion Physics Planning Committee (FPPC), the Fusion Technology Planning Committee (FTPC), and the US-Japan Joint Project (FRONTIER). In particular, the JIFT activities are coordinated with the four FPPC areas of activity, viz., core plasma phenomena, edge behavior and control, heating and current drive, and new approaches and diagnostics.

4. *PLANS FOR FUTURE ACTIVITIES (PROPOSED 2024-2025 PROGRAM)*

The topics and themes of the exchange activities that have been proposed for the next year (April 1, 2024–March 31, 2025) are consistent with the traditional emphasis of JIFT on fundamental theoretical plasma physics issues. At the same time the proposed activities have direct relevance to the fusion science programmatic interests of both countries. The schedule of proposed activities for the coming year (2024-2025) is listed below.

A. 2024-2025 Proposed Workshops

Japan to US:

JWJ1 US-Japan Joint Institute Fusion Theory (JIFT) Collaboration Meeting on Exascale Computing
Organizers: Robert Hager (PPPL) and Toseo Moritaka (NIFS)
Proposed Place/Time: Nov. 11-12, 2024 at PPPL (US)

B. 2024-2025 Proposed Exchange Visits

Japan to US:

JPU1 Kinetic turbulence simulation of helical confinement plasmas using graphics processors
Visiting Scientist: Tomoya Tatsuno (UEC)
Location: The University of Maryland
Dates: Sep. 8-22, 2024

JPU2 Collaboration on Tokamak boundary plasma turbulence simulations for divertor heat flux width
Visiting Scientist: Haruki Seto (QST)
Location: Lawrence Livermore National Laboratory
Dates: Aug. 5-16, 2024

US to Japan:

JPJ1 Collaboration on Tokamak boundary plasma turbulence simulations for divertor heat flux width
Visiting Scientist: Ben Zhu (LLNL)
Location: QST
Dates: Sep. 2-6, 2024

JPJ2 The application of the metriplectic formalism to guiding-center transport theory
Visiting Scientist: Alain J. Brizard (Saint Michael's College)
Location: NIFS
Dates: Jun. 3-July 3, 2024

JPJ3 Multi-scale turbulence interactions and transport modeling
Visiting Scientist: Cole Stephens (The University of Texas at Austin)
Location: NIFS
Dates: July 24-31, 2024