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

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

DATE: April 8, 2022

SUBJECT: JIFT Annual Report of Activities for 2021-2022

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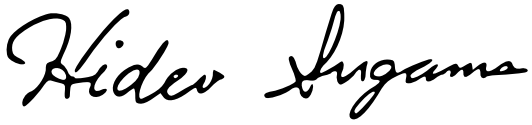

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Annual Report of Activities

US-Japan Joint Institute for Fusion Theory

April 1, 2021–March 31, 2022

JIFT Steering Committee

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

Co-Executive Secretaries: S. Ishiguro and A. Arefiev

April 8, 2022

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1. *INTRODUCTION*

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

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.

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 41 years of successful operation, JIFT has sponsored 246 long-term visits by exchange scientists and 139 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 (2021-2022 PROGRAM)*

Some of the activities in the two categories—workshops and personal exchanges—that had been scheduled for the 2021-2022 JIFT program were canceled because of the COVID-19. However, one personal exchange was successfully carried out while one online workshop and seven remote collaborations were done rather than in person. The JIFT Steering Committee meeting was held online for discussing schedules for the 2021-2022 and 2022-2023 JIFT programs.

Summary reports about JIFT activities for 2021-2022 are given below.

A 2021-2022 Workshops

Japan to US:

JF-1 US-Japan collaborations on co-designs of fusion simulations for extreme scale computing
Organizers: C.S. Chang (PPPL) and Masanori Nunami (NIFS)
Location: ONLINE
Dates: January 18-19, 2022 (Japan time), January 17-18, 2022 (US time)

The purpose of this workshop was to promote US-Japan collaborations on co-design of fusion applications and simulations towards extreme scale computing. In the collaboration, we shared not only the status of the progress in the simulation researches for fusion science, but also the latest technology of the high-performance computing (HPC) including the flagship computers in the US and Japan. This was held ONLINE and this was the 6th in the series of JIFT workshops on the collaboration. The workshop was attended by 21 participants, and there were 8 oral presentations (4

from the US, 4 from Japan) that are covered the fusion plasma simulations and HPC technologies. The agenda can be obtained from the workshop web site;
https://workshop.nifs.ac.jp/jiftws/

JF-2 Theory and simulation on the high field and high energy density physics
Organizers: Alexey Arefiev (UCSD) and Y. Sentoku (Osaka)
Location: Pittsburgh, PA (US)
Dates: November 12-13, 2021
This workshop was canceled.

US to Japan:

JF-10 Progress on advanced optimization concept and modeling in stellarator-heliotrons
Organizers: S. Murakami (Kyoto) and D. Anderson (Univ. Wisconsin)
Location: Kyoto (Japan)
Dates: September 22-24, 2021
This workshop was canceled.

B. 2021-2022 Exchange Visits

Japan to US:

JF-3 Collaboration on Tokamak boundary plasma turbulence simulations for divertor heat flux width
Visiting Scientist: Haruki SETO (QST)
Location: Lawrence Livermore National Laboratory, California, USA
Dates: April 1, 2021 – Mar. 31, 2022; via monthly TV meetings between QST and LLNL (virtual)
Summary:
In this project, Dr. H. Seto (QST, JA) and Dr. X.Q. Xu (LLNL, US) conducted a joint research on the numerical improvement of off-resonant and long-wavelength modes for electromagnetic fields in divertor heat load simulations using BOUT++ code via TV meeting instead of the A3 personnel exchange from QST (JA) to LLNL (US) due to COVID19 issue. BOUT++ and gyrokinetic code XGC1 report that the power fall-off length in ITER can be wider than the value evaluated by extrapolating the experimental scale law [Eich NF2013], which is one of key issues for estimating the lifetime of divertor in ITER. This project is therefore important to predict the operation window of ITER more reliably using BOUT++ code. In this fiscal year, Dr. H. Seto developed a novel numerical scheme handling off-resonant and long-wavelength modes for electromagnetic fields and has been implementing it into the BOUT++ turbulence module for heat turbulence transport simulations, and Dr. X.Q. Xu provided an input of ITER simulation reported in the previous work [Xu NF2019] as a test data for the code development. We are continuing to develop the module for the personnel exchanges under JIFT collaboration planned in FY2022.

JF-4 Ignition and burn dynamics of magnetized fast ignition laser fusion
Visiting Scientist: T. Johzaki (Hiroshima Univ)
Location: Purdue Univ. Indiana (US)
Dates: February 28-March 4, 2022
This collaboration is to be done online.

JF-5 Simulation study of interchange mode dynamics
Visiting Scientist: Katsuji ICHIGUCHI (NIFS)
Location: Massachusetts Institute of Technology, Massachusetts (US)

Host scientist: Linda E. Sugiyama
Dates: April 1 - December 17, 2021 (Email exchanges)
Summary:

Due to the pandemic of the COVID-19, Dr. Ichiguchi and Dr. Sugiyama collaborated by means of the frequent email discussion instead of the real visiting. They obtained the following result. A transition from an interchange mode to a non-resonant mode is found in the nonlinear magnetohydrodynamic (MHD) simulation for the partial collapse in a Large Helical Device (LHD) plasma with a net toroidal current. This transition can occur when the magnetic shear is weak and the rotational transform is close to unity in the core region. In this transition, the mode number of the dominant Fourier component is reduced. As a result of the nonlinear evolution, the (m,n)=(1,1) component can be dominant, where m and n are the poloidal and the toroidal mode numbers, respectively. This transition is considered to be a candidate to explain the observation in the LHD experiments with the net toroidal current that show partial collapses are caused by the (1,1) mode. This result was reported as
K. ICHIGUCHI, Y. SUZUKI, Y. TODO, S. SAKAKIBARA, K. IDA, Y. TAKEMURA, M. SATO, S. OHDACHI, Y. NARUSHIMA, L. SUGIYAMA, B. A. CARRERAS, 'NON-RESONANT GLOBAL MODE IN LHD PARTIAL COLLAPSE WITH NET TOROIDAL CURRENT' at 28th IAEA Fusion Energy Conference (FEC2020), 10-15 May 2021,
and is published as
K. Ichiguchi, Y. Suzuki, Y. Todo, S. Sakakibara, K. Ida, Y. Takemura, M. Sato, L.E. Sugiyama and B.A. Carreras 'Non-resonant global mode in LHD partial collapse with net toroidal current' in Nuclear Fusion 61 (2021) 126056 (8pp).

JF-6 Theoretical study on high energy density plasma creation and ion acceleration by kJ-class intense lasers

Visiting Scientist: Natsumi Iwata (Osaka University)
Location: Online
Dates: April 20 – December 16, 2021 (15 days)
Summary:

This exchange activity was carried out online from April 20, 2021 to December 16, 2021. Due to the spread of COVID-19 infection, it was not possible to visit the counterpart organization, Lawrence Livermore National Laboratory (LLNL), but we had a total of 15 remote meetings of about one hour each, mainly with laser plasma theorists Dr. Wilks and Dr. Kemp at LLNL. Dr. Iwata has been collaborating with them on ion acceleration by kJ-class lasers such as LFEX laser at Osaka University and NIF-ARC laser at LLNL. The purpose of this exchange activity was to develop a theoretical model of high-energy-density plasma formation and ion acceleration by the kJ intense lasers through discussions with LLNL researchers. As a result of the remote meetings, we published a paper in June 2021 [1]. Furthermore, to experimentally verify the theory presented in this paper, we organized a team of Japan and U.S. researchers. Dr. Iwata led the team as the principal investigator and submitted an experimental proposal to the NIF Discovery Science open call for 2021 during this exchange activity. The proposal was awarded two shot days at the NIF laser facility. This progress will further accelerate Japan-U.S. collaboration on high intensity laser-plasma interaction and high energy density physics.
Related publication:
[1] N. Iwata, A. J. Kemp, S. C. Wilks, K. Mima, T. Ma, D. Mariscal, and Y. Sentoku, “Lateral confinement of fast electrons in intense laser-thin foil interactions”, Physical Review Research 3, 023193 (2021)

JF-7 Optimization study of heliotron configurations

Visiting Scientist: H. Yamaguchi (NIFS)
Location: Univ. Wisconsin (US)
Dates: July 28-Aug.31, 2021

This exchange visit was canceled.

JF-8 Integrated transport simulation of HSX plasma
Visiting Scientist: Y. Morishita (Kyoto)
Location: Univ. Wisconsin (US)
Dates: Sep. 26-Oct.24, 2021
This exchange visit was canceled.

JF-9 Theoretical study related to two-fluid equilibria
Visiting Scientist: A. Ito (NIFS); visiting researcher in IFS
Location: IFS, University of Texas at Austin (US)
Dates: Jan.12-Feb.15, 2022; paid by US
Summary:

Dr. Ito discussed with Prof. F. L. Waelbroeck at Texas to start collaboration. Dr. Ito has been working on the study of two-fluid MHD equilibrium with flow and finite Larmor radius based on reduced MHD. The following three topics to extend the previous studies were discussed.

- Shock structure in toroidal equilibria with flow

The shock structure caused by transonic poloidal flow models pedestal structure in density profile in tokamak H-mode. In ideal MHD, the shock structure becomes discontinuous. The possibility of regularization of the discontinuity by the two-fluid effects, in analogy to the resolution of Alfven singularity, was discussed.

- Equilibrium calculation in the presence of flow and magnetic island

The possibility of the numerical analysis of effects of poloidal flow and diamagnetic drifts on equilibrium with magnetic island based on the reduced MHD equilibrium model was discussed.

- Formation of current sheets due to shear flow in forced reconnection

In forced magnetic reconnections in MHD, the current sheets are formed by the Alfven resonance of plasma flow. The possibility of analyzing two-fluid effects in analogy to the theory of tearing mode instability.

On February 9, Dr. Ito presented a seminar, titled "Two-fluid and finite Larmor radius effects on high-beta tokamak equilibria with flow in reduced MHD" at IFS. There were 5 participants on site and 5 participants online. Parameter regions of flow velocity and applicability of equilibrium to gyrokinetic simulations were discussed.

US to Japan:

JF-11 Theoretical model of WDM regime driven by intense laser
Visiting Scientist: Frank Graziani (LLNL)
Host Scientist: Yasuhiko Sentoku (ILE, Osaka University)
Location: Institute of Laser Engineering, Osaka University
Dates: online
Summary:

Dr. Graziani is a theorist working on the High Energy Density (HED) plasma, especially, in Warm Dense Matter (WDM) regime, produced by ultra-intense laser light. The purpose of his visit is to collaborate to establish a physics model of WDM. Dr. Graziani is a director of HED science center in LLNL and initiate the education for graduate students in US. Due to the COVIT situation, it was not possible to travel from the U.S. to Japan this year. Therefore, Drs. Granziani and Sentoku had on-line meeting on 05/25, 07/08, 08/19, 8/26, 9/29, 11/10, and 11/24 in 2021, for about one hour each, from 9:00 a.m. Japan time. In addition, they discussed the next year's plan to promote the exchange of researchers between Japan and the U.S. via e-mail. As an example of their activities, they started the Japan-U.S. Joint Seminar series for HEDS once a month from December,2021. Two seminars have been held so far, each with about 100 participants, contributing greatly to exchange researchers' recent research progress both in the U.S. and Japan.

JF-12 Properties of high-energy-density material

Visiting Scientist: T. Ogitsu (LLNL)
Location: Osaka University (Japan)
Dates: June 7-11, 2021
This exchange visit was canceled.

JF-13 Novel setups for laser-plasma interactions involving structured targets and applied magnetic fields
Visiting Scientist: Alexey Arefiev (UCSD)
Host Scientist: Yasuhiko Sentoku (ILE, Osaka University)
Location: Institute of Laser Engineering, Osaka University
Dates: online
Summary:
Prof. Sentoku and Prof. Arefiev are working on theoretical simulations of non-equilibrium high-energy density plasmas produced by the interaction of ultra-intense laser and matter. In particular, they are collaborating on the development of a simulation code with the aim of elucidating the fundamental physics of electron-ion acceleration, X-ray radiation, laser propagation under high magnetic fields, and pair-creation processes. This year, Prof. Arefiev could not travel to Japan because of the COVID situation. They had online meetings on 04/15, 6/17, 7/21, 8/18, 8/25, 9/8, 9/15, 10/5, 10/15, 10/19, 11/2, 11/18, 11/30, 12/21 in 2021, and 01/19 and 01/26 in 2022 for about 1 hour each from 9:00 a.m. at Japan time. They discussed the ultra-intense laser-plasma interaction in the plasma channel and the strong magnetic field structure generated there, as well as the dynamics of gamma-ray emissions and electron-positron pair productions. The discussions are very fruitful, and they are planning to write a joint paper for that.

JF-14 Isochoric heating by fast ion beam driven by intense laser light
Visiting Scientist: A. Pak (LLNL)
Location: Osaka University (Japan)
Dates: July 7-14, 2021
This exchange visit was canceled.

JF-15 Collaboration on Tokamak boundary plasma turbulence simulations for divertor heat flux width
Visiting Scientist: Xueqiao XU (LLNL)
Location: Rokkaho Fusion Institute, National Institutes for Quantum Science and Technology, Japan
Dates: April 1, 2021 – Mar. 31, 2022; via monthly TV meetings between QST and LLNL (virtual)
Summary:
In this project, Dr. H. Seto (QST, JA) and Dr. X.Q. Xu (LLNL, US) conducted a joint research on the numerical improvement of off-resonant and long-wavelength modes for electromagnetic fields in divertor heat load simulations using BOUT++ code via TV meeting instead of the A4 personnel exchange from LLNL (US) to QST (JA) due to COVID19 issue. BOUT++ and gyrokinetic code XGC1 report that the power fall-off length in ITER can be wider than the value evaluated by extrapolating the experimental scale law [Eich NF2013], which is one of key issues for estimating the lifetime of divertor in ITER. This project is therefore important to predict the operation window of ITER more reliably using BOUT++ code. In this fiscal year, Dr. H. Seto developed a novel numerical scheme handling off-resonant and long-wavelength modes for electromagnetic fields and has been implementing it into the BOUT++ turbulence module for heat turbulence transport simulations, and Dr. X.Q. Xu provided an input of ITER simulation reported in the previous work [Xu NF2019] as a test data for the code development. We are continuing to develop the module for the personnel exchanges under JIFT collaboration planned in FY2022.

JF-16 Long time simulations of energetic particle driven instabilities
Visiting Scientist: D.A. Spong (ORNL)
Location: NIFS (Japan)

Dates: November 29-December 3, 2021
This exchange visit was canceled.

JF-17 Kinetic-MHD hybrid simulations of energetic-particle driven instabilities
Visiting Scientist: Chang Liu (PPPL)
Location: NIFS (Japan)
Dates: July 5-August 6, 2021
Summary:
This exchange visit was canceled.

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	S. Ishiguro (NIFS)—Co-Exec. Secretary
D. Spong (ORNL)	S. Murakami (Kyoto)
J. Mandrekas (DOE)	Y. Sentoku (Osaka)

JIFT Advisors

Japanese Advisory Committee: Y. Todo (NIFS), 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) and the Fusion Technology Planning Committee (FTPC). 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 2022-2023 PROGRAM)*

The topics and themes of the exchange activities that have been proposed for the next year (April 1, 2022–March 31, 2023) 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 (2022-2023) is listed below.

A. 2022-2023 Proposed Workshops

Japan to US:

JF-1 Theory and simulation on the high field and high energy density physics
Organizers: Alexey Arefiev (UCSD) and Y. Sentoku (Osaka)
Proposed Place/Time: Oct.15-16, 2022 at Spokane, WA (US)

B. 2022-2023 Proposed Exchange Visits

Japan to US:

JF-2 Modeling of gamma-ray emission and BW pair creation driven by ultra-intense laser light
Visiting Scientist: K. Sugimoto (Osaka Univ)
Location: UCSD
Dates: June 26-July 3, 2022

JF-3 Collaboration on Tokamak boundary plasma turbulence simulations for divertor heat flux width
Visiting Scientist: H. Seto (QST)
Location: Lawrence Livermore National Laboratory
Dates: Aug. 14-27, 2022

JF-4 Development of radiation ray tracing code system for implosion core diagnosis and its application
Visiting Scientist: T. Johzaki (Hiroshima Univ)
Location: Purdue Univ.
Dates: Sep. 3-17, 2022

JF-5 Optimization of three-dimensional plasma confinement configuration with helical coils and permanent magnets
Visiting Scientist: H. Yamaguchi (NIFS)
Location: Univ. Wisconsin and PPPL
Dates: July 31-September 30, 2022

US to Japan:

JF-6 Theoretical model of WDM regime driven by intense laser
Visiting Scientist: F. Graziani (LLNL)
Location: Osaka Univ.
Dates: June 6-10, 2022

JF-7 Modeling of pair-creation in intense laser-plasma interaction
Visiting Scientist: A. Arefiev (UCSD)
Location: Osaka Univ.
Dates: July 11-15, 2022

JF-8 Collaboration on Tokamak boundary plasma turbulence simulations for divertor heat flux width
Visiting Scientist: Xueqiao Xu (LLNL)

Location: QST
Dates: Nov. 13-26, 2022

JF-9 Kinetic-MHD hybrid simulations of energetic-particle driven instabilities
Visiting Scientist: Chang Liu (PPPL); recommended as a candidate for a visiting researcher in NIFS
Location: NIFS (paid by NIFS)
Dates: Aug. 29-Sep. 30, 2022