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

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

DATE: March 31, 2015

SUBJECT: JIFT Annual Report of Activities for 2014-2015

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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, 2014–March 31, 2015

JIFT Steering Committee

Co-Chairmen: R. Horiuchi and F. L. Waelbroeck

Co-Executive Secretaries: H. Sugama and A. Arefiev

March 31, 2015

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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 34 years of successful operation, JIFT has sponsored 211 long-term visits by exchange scientists and 123 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 several weeks to two or three months in duration, whereas the Visiting Professors normally stay for three months.

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 (2014-2015 PROGRAM)*

Almost all of the activities in the two categories—workshops and personal exchanges—that had been scheduled for the 2014-2015 JIFT program were carried out during the past year. Four workshops were successfully held, in addition to the JIFT Steering Committee meeting. In the category of personal exchanges, two Visiting Professor and eleven Visiting Scientists made exchange visits.

Summary reports about JIFT activities for 2014-2015 are given below.

A. 2014-2015 Workshops

US to Japan:

JF-10 ***Present status and prospects of theory and simulation on 3D physics in toroidal plasmas (with the emphasis on Stellarator-Heliotrons and RFPs)***
Organizers: Masayuki Yokoyama (NIFS) and Chris C. Hegna (Univ.Wisconsin-Madison)
Location: Institute of Advance Energy, Kyoto University, Uji, Kyoto
Dates: June 3-5, 2014
Summary:

The purpose of this workshop was to promote common understandings on three-dimensional physics which has been highlighted in many issues in toroidal plasmas.This was the counterpart workshop following the first one held in Madison last year. The workshop was attended by around 20 participants including occasional appearance of Kyoto University researchers and students. There were 14 oral presentations (4 from the US, 10 from Japan), which covered a wide range of subjects related to the development and application of theory and simulation on 3D physics issues, such as interaction between

ECCD and Alfven eigenmodes, impacts of 3D geometry on pedestal formation in DIII-D, neoclassical toroidal viscosity in JT-60U (NIFS-JAEA collaboration), electromagnetic gyrokinetic simulation for finite-beta LHD plasmas, 3D equilibrium analyses in tokamaks and the construction of chaotic coordinates (based on the outcome of the JIFT-visiting professorship in FY2013). This workshop will be extended as the joint theory-experiment meeting on 3D physics (already applied), based on this 2-years successful workshops.

Related publications:

The agenda and presentation files are available through the web site below. (http://ishcdb.nifs.ac.jp/US-JP_JIFT_WS.html).

JF-11 ***Recent studies of extended MHD and MHD simulations***

Organizers: Hideaki Miura (NIFS), Linda E. Sugiyama (MIT)
Location: Kyoto University, Kyoto
Dates: June 5-6, 2014
Summary:

This workshop was aimed at promoting the activities on fully three-dimensional simulations of MHD or extended MHD equations for studying linear and nonlinear growth of unstable modes in various fusion experiments. This was the second workshop in the series of JIFT workshops on this subject. Twenty participants attended the workshop, including three US researchers. There were 13 oral presentations, covering various topics such as linear and nonlinear growth of ballooning modes, diamagnetic (or two-fluid) effects on the ballooning/ interchange/g- modes, energetic-particle effects on instabilities, heat transport, analysis of ELMs by the use of Lyapunov exponents, and so on. Among the topics, many of the presenters mentioned two-fluid effects, reflecting a large trend in three-dimensional numerical simulations of instability.

Japan to US:

JF-1 ***US-Japan workshop on progress in kinetic plasma simulations***
Organizers: Alex Arefiev (IFS, US), Hiroaki Ohtani (NIFS, Japan).
Location: New Orleans, Louisiana, US
Dates: 31 October - 1 November, 2014
Summary:

This was the 7th workshop in the series of JIFT workshop focused kinetic plasma modeling. The three main goals of the workshop were 1) to highlight the progress in development of new algorithms and the improvements made to the existing ones; 2) to present new results obtained using kinetic plasma simulations; 3) to discuss the new physics aspects that need to be considered when performing kinetic plasma simulations. Plasma kinetic simulations are used to tackle a wide ranging of problems from fusion plasmas to plasmas irradiated by high intensity lasers. The diversity of these problems has stimulated development of novel yet very specific techniques to address the issues of interest. Typically, the discussion of these techniques is confined to a small community of researchers working on a specific topic. The purpose of this workshop was to bring different communities together for an exchange of ideas. There were 10 participants from Japan and 16 from US. There were 22 oral presentations (8 From Japan and 14 from US).

Related publications:

Abstract, presentations, agenda, and workshop photos are available at (http://www-fps.nifs.ac.jp/ohtani/JIFT2014/).

JF-2 ***US-Japan workshop on fast ignition and relevant high-energy-density physics***
Organizers: Alex Arefiev (IFS, US), Atsushi Sunahara (ILT, Japan), Juan Fernandez (LANL, US), Farhat Beg (UCSD, US).
Location: Austin, Texas, US
Dates: November 3-4, 2014
Summary:

The purpose of the workshop was to update the participants on the current progress and results in fast ignition research. The topics discussed at the workshop covered fast ignition and relevant high-energy-density physics (electron/ion based fast ignition physics; innovative ignition concepts; hot electron transport in plasmas; fast electron generation; proton/ion production and transport; magnetized HED plasmas; applications in ICF, ion sources, neutron sources). Twenty-four participants attended the workshop (9 from Japan and 15 from US). There were 21 oral presentations (9 From Japan and 12 from US). There is not website for this workshop.

JF-16 ***JIFT Steering Committee Meeting***
Organizers: François Waelbroeck (IFS) and Ritoku Horiuchi (NIFS)
Location: New Orleans, Louisiana, US
Dates: November 1, 2014
Summary:

Participants at the steering committee meeting reviewed the status of JIFT activities for 2014-15 and discussed recommendations for exchange activities during 2015-16.

B. 2014-2015 Exchange Visits

Japan to US:

JF-3 ***Simulation study of ICRF heating in the quasi-helical symmetric configuration***
Visiting Scientist: Sadayoshi Murakami (Kyoto Univ.)
Location: HSX Plasma Experiment Laboratory, University of Wisconsin, Madison, Wisconsin
Dates: February 3-15, 2015 (13 days); paid by Japan
Research Summary:

Dr. S. Murakami has been collaborated for a number of years with Dr. K. Likin and Dr. J. Talmadge at HSX Plasma Experiment Laboratory, University of Wisconsin on the kinetic behavior of the energetic particles due to the plasma heating in the quasi-hellical symmetric configuration. In this visit they studied the ICRF minority heating in the HSX configuration and the confinement of energetic tail ions and plasma heating efficiency. They found that the energetic ions (E~10keV) are well confined if the helical symmetric magnetic configuration is assumed, but a large number of energetic ions lost by the orbit loss due to the unstable behavior of trapped ions if the quasi-symmetric magnetic configuration which includes subtle non-symmetric modes are assumed. The amplitudes of these non-symmetric modes are small but A large effect on the energetic ion confinement can be seen. The heating efficiency of the ICRF minority heating in the HSX plasma is calculated. They found that the power loss by charge exchanges with the neutral particles is larger in the small device like HSX. Also they found that the charge exchange power loss is increased more in the good quasi-symmetric configuration than that in the mirror increased configuration due to the better confinement of the energetic ions. Therefore the reduction of the neutral particle will improve the heating efficiency of the ICRF minority heating in the HSX plasma. They also discuss the possibility of the NBI heating in the HSX plasma to study the kinetic behavior of the energetic particles in the quasi-symmetric configuration and Dr S. Murakami has started to install the NBI heating analysis code, FIT3D, to the HSX configuration.

JF-4 ***Simulation study on L-H transition using BOUT++ code***
Visiting Scientist: George Breyiannis (JAEA-Rokkasho)
Location: LLNL, Livermore, CA, USA
Dates: July 22- Aug 2, 2014 (12 days); paid by Japan
Research Summary:

This was a reciprocal visit in order to further solidify the collaboration between JAEA-Rokkasho and LLNL on the development and use of the BOUT++ framework. Dr Xu has visited Rokkasho in Sep/Oct 2013 and the collaboration has been ongoing since then. A number of new tools were developed in Rokkasho and the integration of BOUT++ into the iferc-csc (HELIOS) platform has been successfully achieved [1]. The purpose of the visit was to present and integrate the recently developed pre and post processing tools into the LLNL workflow [2]. This included addressing dependency issues in their platform, a presentation of the new capabilities and a training session for the local users on the new tools.

A number of meetings with the local developers provided feedback on future extensions and the corresponding roadmap in addition to clarifications on numerics and applications involved. In addition, the users in LLNL were introduced to the iferc-csc computer platform and remote execution of runs and analysis tools was demonstrated. Several issues regarding nonlinear simulations, benchmarking and workflow management were addressed. Participation in a number of meetings held in LLNL during this visit provided an insight and perspective into their research program facilitating better coordination of future collaborations.

Related publications:

[1] G Breyiannis, M Yagi, B D Dudson and X Q Xu, "Integration of BOUT++ numerical framework into IFERC-CSC", 10th Fission Fusion Energy Association Conference, Tsukuba, Japan.

[2] B. D. Dudson, A. Allen, G. Breyiannis, E. Brugger, J. Buchanan, L. Easy, S. Farley, I. Joseph, M. Kim, A. D. McGann, J. T. Omotani, M. V. Umansky, N. R. Walkden, T. Xia and X. Q. XuBOUT++: Recent and current developments. Journal of Plasma Physics, Available on CJO2014, doi:10.1017/S0022377814000816.

JF-5 ***Gyrokinetic simulations of microtearing instability***

Visiting Scientist: Ryusuke Numata (Univ. Hyogo)
Location: University of Maryland, College Park, Maryland
Dates: August 31-September 13, 2014 (14 days); paid by Japan
Research Summary:

Dr. Numata has been working with Prof. W. Dorland at the University of Maryland at College Park, since he was a research fellow there. He developed a gyrokinetics code in a slab geometry (AstroGK) with Prof. Dorland and others, and has been utilizing the code to analyze magnetic reconnection in strongly magnetized plasmas. He visited UMD under the JIFT program to extend the linear analysis of the tearing instability to include pressure gradient effects. Pressure gradients can drive a tearing instability (microtearing (MT) instability). It is theoretically predicted that the MT mode is a microscopic mode such that the mode is unstable for small scale perturbations (smaller than the typical scale of magnetic shear, i.e. Delta' is negative), and the mode is most unstable if the collision frequency is comparable with the drift frequency. To verify this theoretical prediction in the gyrokinetic framework, linear simulations using AstroGK have been performed. The results qualitatively confirm theorical predictions: i) the MT instability is most unstable when the collision frequency is nearly equal to the drift frequency and is stable for smaller/larger collisionality indicating in-exisitense of the 'collisionless' MT mode in slab plasmas, ii) an energy dependent collision frequency is indispensable for the MT mode to grow. Although the gyrokinetic simulations have reproduced the theoretical prediction qualitatively, there is quantitative discrepancy. Dr. Numata continues the collaboration to develop a deeper understanding of the mechanism of the slab MT instability.

Related publications:

A. Zocco, N.F. Loureiro, D. Dickinson, R. Numata, and C.M. Roach, "Kinetic microtearing modes and reconnecting modes in strongly magnetized slab plasmas," submitted to Plasma Phys. Control. Fusion (2014).

JF-6 ***Development and Its Applications of innovative scheme of numerical simulation for relativistic laser-plasma interactions in fast ignition laser fusion***

Visiting Scientist: T. Johzaki (Hiroshima)
Location: University of Nevada, Reno
Dates: March 2 - March 9, 2015 (8 days); paid by Japan
Research Summary:

Dr. Johzaki has been collaborating for a number of years with Prof. Y. Sentoku at University of Nevada, Reno (UNR) on the simulation study for the relativistic laser plasma interaction related to the laser fusion. Dr. Johzaki has developed the Fokker-Planck codes for fast electron transport and fast ions, and then analyses and optimizes the processes of those fast particles generation and energy transport to the imploded core for the fast ignition laser fusion. Prof. Sentoku has developed PIC code including particle collision, ionization and radiation damping processes. In the past collaboration, they have developed the simulation model for the collision and ionization, and then have revealed the effects of collisional processes on the fast electron transport in the high Z Au cone. In these collaboration works, they came around the idea for enhancing the core heating efficiency, which is the core heating by ion beam generated by radiative pressure acceleration with circularly-polarized ultra-intense laser pulse. In the 2012 exchange program, they have carried out the one-dimensional integrated simulations (PIC simulations for beam generation and Fokker-Planck simulations for core heating) and demonstrated the potential probability for C^{6+} beam driven fast ignition laser fusion. In the 2013 exchange program, they have developed a 2D transport code for fast ion based on the particle method, and carried out two-dimensional integrated simulations (PIC for beam generation and hybrid simulation for core heating) by assuming the more realistic situation. Through this exchange program, they showed the laser and target conditions required for generation of C^{6+} beam used for core heating driver in fast ignition laser fusion.

In this fiscal year (2014), to make further development of their PIC code including collisional processes, ionization and radiation transport for the research on laser fusion and related relativistic laser plasma physics, they have discussed about the following topics:

(1) Numerical modeling for taking the following physical processes into account
  a) Nuclear reaction (e.g., (γ, n) reactions, electron-positron pair creations by γ-rays)
  b) Compton scattering of γ-ray
  c) Recombination processes (inverse process of ionization)
  d) Auger photoelectron processes

(2) Particle merging scheme for suppressing the increase in the number of super-particle due to the particle generation by various reaction processes

(3) New scheme for improving the accuracy of radiation transport

(4) Numerical scheme for highly concurrent computation

Some of the above topics can be introducing in to the current PIC code easily, and the further considerations are required for the some topics. Anyhow, we have had the deep and useful discussion. In addition, we have discussed with Prof. Hiroshi Sawada (Experimentalist @ UNR) about experiments for relativistic laser plasma interactions and implosion of spherical shell targets related to fast ignition, and we have obtained the latest findings and the direction of future collaboration works related to the experimental analysis of the laser fusion

JF-7 ***Development of Laser Plasma Analysis Code and Framework for Distributed Visualization***

Visiting Scientist: Hitoshi Sakagami (NIFS)
Location: University of Nevada, Reno
Dates: February 22 - March 7, 2015 (14 days) paid by Japan
Research Summary:

There are two major relativistic PIC codes, namely OSIRIS and PICLS, which are used by many laser-plasma researchers, and Prof. Sentoku, who is the host for this visit to University of Nevada, Reno, is developer of PICLS. He has very variety of experiences about PIC code, and we can fruitfully discuss about issues for advanced PIC code. In fast ignition PIC simulations, using weighted particles is mandatory, and particle merging is necessary to avoid increment of number of particles in the advanced PIC code. Simply merging two particles under conservation of momentum and energy causes distortion in velocity distribution function, and it does not work. On the other hand, PIC simulations for laser-matter interactions should be carried out even after laser irradiation. In such time, plasma temperature decreases and recombination process plays an important role. Although calculation of recombination is very difficult in PIC simulations because recombination is based on three body collisional processes, recombination treatment is also necessary in the advanced PIC code. Finally, we get new ideas to solve both issues after long discussion with Prof. Sentoku. We also parallelize the PIC code using the framework called “OhHELP” under collaboration with Prof. Sentoku, and adopt it for special boundary condition, namely Perfect Matching Layer boundary.

JF-8 ***Simulation study of magnetized fast ignition fusion***

Visiting Scientist: Toshihiro Taguchi (Setsunan University)
Location: Institute for Research in Electronics and Applied Physics, University of Maryland, College Park, Maryland
Dates: August 10 - September 7, 2014 (29 days); paid by Japan
Research Summary:

Dr. Toshihiro Taguchi has been collaborating with Dr. T. M. Antonsen, Jr. for many years on a simulation study about laser-plasma interaction. One of recent topics of the field is the laser-plasma interaction under a strong magnetic field. In the experimental research in Osaka University, kilotesla-class magnetic field generation has been successfully achieved and it is expected to develop a new field so-called the magnetized laser-plasma. One of its major applications is a fast ignition fusion. In the scheme, the relativistic electrons passing through a high density region plays a key role to ignite a fuel core plasma. In the transport of the electrons, several instabilities take place and they prevent electrons from passing straightly in the plasma. The wide divergence angle of electrons degrades the transmission efficiency from absorbed laser energy to heating energy of the core.

During Dr. Taguchi's visit in 2014, Dr. Antonsen and he studied about the nonlinear evolution of the instability between an electron beam and background electrons. According to their recent research showed that the Weibel instability, which is an electromagnetic two-stream instability, is possible to be suppressed under a very strong magnetic field. However, during the nonlinear evolution of the instability, it shows rather complicated structures. First, the transverse unstable mode separates the electron stream into narrow filaments. When there is no magnetic field, the filaments are merged by a mutual current attractive force. However in the strong magnetic field, the transverse motion is suppressed and the filaments flow laminarly. On the other hand, the strength of the applied magnetic field is not sufficient, the electron flow is stagnated and the flux is reduced more than the case of no magnetic field. Dr. Taguchi and Dr. Antonsen, conducted many simulation runs in a range of external parameters, such as electron speed, temperature, and external magnetic field strength. They finally concluded that the stopping force of the electron beam is exerted by a slow electromagnetic wave, whistler wave. Then we selected the second subject of the collaboration to search the reason why such a strong whistler wave is excited in the magnetized laser-plasma interaction. They checked many possibilities of the generation of the wave, but have not obtained the final answer. In the research, we found that the whistler wave generation is not a linear process but a nonlinear one. The investigation is still continuing.

Related publications:

[1] T. Taguchi, T. M. Antonsen1, Jr. and K. Mima, “Control of the Weibel instability and structure formation by a strong magnetic field”, PLASMA2014 symposium abstract (2014).

[2] T. Taguchi, T. M. Antonsen1, Jr. and K. Mima, “Suppression of beam merging and hosing instabilities in the magnetized fast ignition”, in Proceedings.

JF-9 ***Passive-scalar and passive particle simulations in a magnetized plasma***

Visiting Scientist: Hideaki Miura (NIFS)
Location: University of Texas, Austin
Dates: March 4-30, 2015 (27 days); paid by IFS
Research Summary:

This program has been approved for a study of passive particles in magnetized plasma. All the costs including travel fair and daily expenses are covered by the U.S. side. Miura has been collaborating with Dr. Wendell Horton on the subject since Dr. Horton visited NIFS in 2012 for collaboration with Dr. Sudo, Dr. Tanaka and Dr. Tamura in NIFS. Techniques of fluid simulations with passive particles are going to be applied for a study of high-Z impurities in a torus plasma device. Miura has discussed with the counter person, Dr. Wendell Horton, about the applicability of the passive particle simulation techniques to a test pellet experiments of the Large Helical Device (LHD) in NIFS. Miura and Dr. Horton have discussed also on a possible study of fluid simulations with a transport of multiple-ion- species by Miura’s fluid code, MINOS, so that we can study low-Z impurities as well. Formulae for studying the passive particles as well as the multiple-ion-species are described so that the code can modified for the subject. The passive particle code is now the modification so that it can be used in a massively parallel supercomputer. Also, as a secondary subject of the fluid simulations with passive particle, a mechanism of generating a strong toroidal flow, being converted from a poloidal flow and advect the particles, is studied. The first paper for this collaborative work is going to be submitted.

US to Japan:

JF-12 ***Simulation of Alfven eigenmodes in toroidal plasmas***

Visiting Scientist: D. Spong
Location: National Institute for Fusion Science, Toki, Japan
Dates: March 2-13, 2015; paid by US

Research Summary:

I visited the National Institute for Fusion Science at Toki, Japan from March 1 to 11, 2015 under the sponsorship of Yasushi Todo. The main goal of my visit was to initiate code benchmarking/verification studies between the gyrokinetic GTC model and the MEGA hybrid particle/MHD model for the case of a TAE instability that had been observed in the LHD stellarator. GTC had recently been extended to 3D configurations. This visit was quite helpful as there are only a few codes in the world that can analyze this type of instability in 3D configurations, including full kinetic effects. By the end of the visit we were able to obtain reasonable agreement between the two codes, taking into account the differences in the physics models. This effort will continue and the results obtained during the visit provide a good foundation for future work. I also discussed use of the PENTA/DKES stellarator neoclassical transport codes that I had developed with Masayuki Yokoyama and co-workers, and provided assistance with the initialization, parallel execution and post-processing routines used with these codes. They would like to incorporate these models in the TASK-3D integrated stellarator modeling effort and apply them to the LHD impurity hole regime. Additionally I provided support and discussed applications of the STELLGAP, AE3D, and DELTA5D models with Kunihiro Ogawa and Kazuo Toi for the analysis of Alfven instabilities and fast ion transport in LHD. On the final day of my visit (March 11) I presented a seminar titled "Development of gyrofluid and gyrokinetic models of energetic particle instabilities," during which I reviewed my recent work in tokamaks and stellarators using these models and described the results obtained during my visit comparing the GTC and MEGA models.

JF-13 ***Theoretical Analysis of Vortex Structures in Plasmas***

Visitng Scientist: S. M. Mahajan
Location: the University of Tokyo
Dates: Jan. 5-14, 2015; paid by US
Collaborators: Prof. Yoshida, Prof. Nishiura and their group.
Research Summary:

1) The possibility of a divertor configuration on the Magnetospheric Confinement Experiment (RT-1) at the University of Tokyo was discussed. At this time, the heat exhaust channels are not investigated. So much thinking and planning must go into designing the divertor configurations- where to place the divertor plate and what changes in the local magnetic geometry may be desirable. The experience of the University of Texas in this regard is likely to be very helpful in evolving an appropriate strategy. The visitor had discussions with Profs. Yoshida and Nishiura and Prof. Nishiura, and Dr. Brent Covele will be pursuing these discussions. We agreed to have periodic Skype conferences to advance the realization of the experiment.
2) The collaboration between Prof. Yoshida of the University of Tokyo and Prof. Mahajan of the University of Texas on issue of fundamental theoretical physics took a significant step during this visit. The fluidization of quantum mechanics and the reverse process, finding an equivalent quantum mechanics for fluids (quantum mechanics of interacting particles) has been a very interesting new frontier for its potential for shedding light on the collective properties of systems where quantum nature of the particles may be of importance. This line of enquiry will be particularly useful for the study of very high energy density physical systems in laboratory (laser produced) as well an astrophysics (gamma ray bursters, supernovae--) Extending the recent formulation of non-linear quantum mechanics of fluidons (Swadesh M Mahajan, Felipe A Asenjo, Int J Theor Phys, DOI 10.1007/s10773-014-2341-0), a new way is being explored to find an appropriate description of generalized vorticity in the "quantum framework".
3) Discussions with Prof. Y.Ogawa on the design of a superconducting reactor of intermediate aspect ratio of 2-2.4 were begun. The lower aspect ratio, allowing a higher elongation, and consequently a higher velocity shear may be necessary for the suppression of micro-turbulence so that a healthy H-mode can be sustained.

JF-14 ***Development of advanced predictive modeling capabilities for LHD***

Visitng Scientist: A. Pankin
Location: National Institute for Fusion Science, Toki, Japan
Dates: June 17 - September 16, 2014; paid by US

Research Summary:

During an extended three-month visit of Dr. Pankin to NIFS, collaboration between scientists at Tech-X Corporation and the integrated modeling group at NIFS has been established. Several uncertainty quantification techniques have been investigated and applied to the analysis of LHD experimental data. The DAKOTA toolkit for the uncertainty quantification, sensitivity analysis, optimization, and calibration studies has been implemented in the TASK3D-a1 code. This new development extends the analysis capabilities of the TASK3D-a1 code. The UQ module in TASK3D-a1 can be used for the computation of error bars for all quantities derived in the interpretive analysis, for the separation of errors that are associated with raw experimental errors and errors related to numerical analysis of experimental data such as numerical fitting, interpolation, and smoothing, for the validation of theory-based models, and for development of empirical scaling laws from interpretive experimental data. These applications are closely related to the main objective of any interpretive modeling code, which is the development of an improved understanding of physics processes in burning plasma. The new UQ capabilities in the TASK3D-a1 code have been used for the analysis of the LHD discharge 114606. It is demonstrated that the error bars for derived quantities depend non-linearly on the error bars of raw experiment data. The results of these preliminary collaborative studies have been reported at the NIFS Simulation Symposium (September 2014; Toki, Japan) [1] and at the APS DPP Meeting (October 2014; New Orleans, LA) [2]. The new code developments on the implementation of UQ techniques in the TASK3D-a1 code will be used in future collaborative work between Tech-X Corporation and NIFS integration modeling group for the verification and validation of theory-based models of burning plasmas in tokamaks and stellarators.

Related publications:

[1]. A. Y. Pankin, M. Yokoyama, R. Seki, C. Suzuki, S.E. Kruger, A. Hakim, A.H. Kritz, T. Rafiq, CPES (EPSI), FACETS and CSWIM teams, “Advanced Techniques in Interpretive and Predictive Transport Analysis of Burning Plasmas: Progress Towards theImplementation of Uncertainty Quantification and Sensitivity Analysis Tools in the TASK3D Code.” Proc. of NIFS Simulation Symposium (10-12 September, 2014; Toki, Japan).

[2]. A. Pankin, M. Yokoyama, R. Seki, C. Suzuki, A. Kritz, and T. Rafiq, “Use of Uncertainty Quantification Techniques for Interpretive and Predictive Transport Analysis of Burning Plasmas.” Proc. of 56th Annual Meeting of the APS Division of Plasma Physics Volume 59, Number 15 (October 27–31, 2014; New Orleans, Louisiana) JO3.00009.

JF-15 ***Extension of MHD Stability Analysis for 3D and Nonlinear Problems***

Visiting Scientist: L. Zheng

Location: National Institute for Fusion Science, Toki, Japan

Dates: May 15-Aug 15, 2014; paid by U.S.

Research Summary:

The nonlinear codes in this field are mainly based on the radial grid algorithm. To meet the requirements for computations of the marginal stability case and perturbed equilibrium, a high-resolution numerical scheme at the singular surfaces is favored. This motivates us to develop an adaptive semi-implicit nonlinear code. This is a relatively big project. However, it is benefited from the collaboration between the National Institute for Fusion Science (NIFS), Japan and Institute for fusion studies (IFS), The University of Texas at Austin. To initiate this project, Dr. Linjin Zheng visited NIFS for three months (May 15 - August 15, 2014) with support by the JIFT visiting professorship. Dr. Yasushi Todo-san hosted the visit. Dr. Todo brings to the collaboration a rich experience on the nonlinear and 3D equilibrium computations. Dr. Zheng has developed the adaptive linear stability code: AEGIS. The AEGIS numerical scheme is being extended to compute the implicit part of the planned semi-implicit nonlinear code. Dr. Zheng has also extended the AEGIS code to compute the nonlinear source term in the planned nonlinear code through an AEGIS-like adaptive formalism. Currently, the semi-implicit numerical scheme has been laid out. The resistive MHD is treated implicitly in this formulation, instead of the ideal MHD one as the NIMROD code does, in order to better deal with the field line reconnection problems, especially in the 3D equilibrium computation. The coding work is still in progress. The progress is steady. We anticipate the completion of the code draft in a few months and will start to test it after that. Therefore, the collaboration between two institutes will continue.

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 Research Project at the National Institute for Fusion Science, and the Japanese co-executive secretary is the director of the Fusion Theory and 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 several members representing a spectrum of Japanese universities and the Japan Atomic Energy Agency; and on the US side there is an Advisory Committee comprised of several 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	R. Horiuchi (NIFS) —Co-Chairman
A. Arefiev (IFS)—Co-Exec. Secretary	H. Sugama (NIFS)—Co-Exec. Secretary
D. Spong (ORNL)	A. Fukuyama (Kyoto)
J. Mandrekas (DOE)	H. Nagatomo (Osaka)

JIFT Advisors

Japanese Advisory Committee: N. Nakajima (NIFS), S. Ishiguro (NIFS), Y. Kishimoto (Kyoto), Z. Yoshida (Tokyo), H. Naito (Yamaguchi), M. Yagi (JAEA), T. Ozeki (JAEA)

*US Advisory Committee***:** P. Catto (MIT), V. Chan (GA), B. Cohen (LLNL), W. Horton (IFS), W. Tang (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.

Note that information about the JIFT program, including annual schedules of exchange activities, can be found on the JIFT web site at http://peaches.ph.utexas.edu/jift/.

4. *PLANS FOR FUTURE ACTIVITIES (PROPOSED 2015-2016 PROGRAM)*

The topics and themes of the exchange activities that have been proposed for the next year (April 1, 2015–March 31, 2016) 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 (2015-2016) is listed below.

A. 2015-2016 Proposed Workshops

Japan to US:

Theory and simulation of 3D physics in toroidal plasmas - comparison to experiments
Organizers: Y.Suzuki (NIFS) and E.J.Strait (General Atomics)
Proposed Place/Time: San Diego (General Atomics), June.1-3, 2015

Extended MHD and MHD simulations for magnetized plasmas
Organizers: H.Miura (NIFS) & L.E.Sugiyama (MIT)
Proposed Place/Time: Golden, Colorado, Aug.10-11, 2015

US to Japan:

Theory and Simulation on the high energy density physics related to the inertial confinement fusion
Organizers: J. Sunahara (ILT) and Juan C. Fernandez (LANL)
Proposed Place/Time: Fukui, Dec.5-6, 2015

Innovations and co-designs of fusion simulations towards extreme scale computing
Organizers: T. Watanabe (Nagoya) and C.S.Chang (PPPL)
Proposed Place/Time: Nagoya, Aug. 20-21, 2015

B. 2015-2016 Proposed Exchange Visits

Japan to US:

Two-fluids simulation of magnetic islands
M. Sato (NIFS), Visiting Professor
University of Texas, Feb.1-26, 2015; paid by US

Collaborations between TASK3D-a (for LHD plasmas) and TRSNAP (for tokamak plasmas)
M. Yokoyama (NIFS), Visiting Professor
PPPL, June 4-14, 2015; paid by US

Development and Its Applications of innovative scheme of numerical simulation for relativistic laser-plasma interactions in fast ignition laser fusion
T. Johzaki (Hiroshima), Visiting Scientist
University of Nevada, Reno, Sep.26 - Oct.19, 2015; paid by Japan

Simulation Study of Magnetized Fast Ignition Fusion
T. Taguchi (Setsunan), Visiting Scientist
University of Maryland, Aug.9 - Sep.6, 2015; paid by Japan

Simulation study of energetic particles in the quasi-helical symmetric configuration
S.Murakami (Kyoto), Visiting Scientist
University of Wisconsin, July 12-26, 2015; paid by Japan

US to Japan:

Construction of Chaotic coordinate in the LHD
Stuart R. Hudson (PPPL), Visiting Professor
NIFS, June 1- Aug. 31, 2015; paid by Japan

Gyrokinetic simulation of Alfven eigenmodes
Zhihong Lin (University of California, Irvine), Visiting Scientist
NIFS, Aug.17-22, 2015; paid by US

Modeling of RMP penetration by 3D MHD codes
Nathaniel Ferraro (General Atomics), Visiting Scientist
NIFS, Dec.6-19, 2015; paid by US

Theoretical Analysis of Topological Constraints in Plasmas
Philip J. Morrison (IFS, U. Texas, Austin), Visiting Scientist

Tokyo, Nov.29 - Dec.5, 2015; paid by US

Non-local transport modeling in LHD plasmas
Diego del-Castillo-Negrete (Oak Ridge National Laboratory), Visiting Scientist
NIFS, July 5-18, 2015; paid by US