3. International Collaboration on Helical Fusion Research – IEA Implementing Agreement for Cooperation in Development of the Stellarator-Heliotron Concept –

1. Overview

The world stellarator-heliotron community has been promoting international collaborations under the auspices of International Energy Agency (IEA) Implementing Agreement on "Development of the Stellarator-Heliotron Concept". The present participating countries in this agreement are Australia, Germany, Japan, Russia, Spain, Ukraine and U.S.A. The Stellarator-Heliotron Executive Committee conducts arrangement of collaboration and endorses proposed activities. The 41sr Stellarator-Heliotron Executive Committee was held in San Diego (USA) in conjunction with the 24th IAEA Fusion Energy Conference. NIFS hosts the web page of this activity at http://iea-shc.nifs.ac.jp/. The summary of international collaboration on fusion research among helical systems is given in the following sections.

2. Joint Activiy: Coordinated Working Group Meeting (CWGM) for Stellarator Heliotron Studies

The 10th Coordinated Working Group Meeting (CWGM10) was held from 6 to 8, Jun. 2012 at Max-Planck Institut für Plasmaphysik in Greifswald, Germany. More than 50 experts (on record, including through videoconference) participated.

The materials presented in 10th CWGM are available at http://ishcdb.nifs.ac.jp/ (⇒CWGM10) for those of you having further interests. Below, you will find the overall summary of the meeting.

This is the memorial 10th meeting of the CWGM. On this occasion, H.Yamada (NIFS) reflected the original ideas, "sharing the goal, and acceleration of the output-outcome wheel", to launch the working group activity by referring materials from the informal meeting in 2003 (Greifswald) on Stellarator Database, and IEA Stellarator Executive Committee meeting in 2004 (Villamoura). The launched CWGM activity has embodied these ideas by promoting the comprehensive and exact understanding of complex physics, through the database, joint experiment, benchmarking and joint papers. It was also pointed out that the CWGM should become an excellent light house for global/domestic programs such as ITPA and also the power plant design activities. Continuous contribution to the ITPA has already been made through "3D physics". In addition to that, reactor session was set up in this 10th CWGM to promote joint efforts in this direction as well. To further promote joint experiments among stellarator-heliotron (S-H) devices, recent and upcoming statuses of the devices are introduced from LHD, TJ-II and Heliotron J (H-J). New systems that will become available are: the increase of ECH and ICH heating power, and closed divertor (cryo-pumping at 1 section and baffle/dome installation at the total 8 sections out of 10 sections) in LHD, the pellet injector and 2nd HIBP (in collaboration with ORNL and Kharkov/Kurchatov Institute, respectively) in TJ-II, and plasma profile measurement by means of several diagnostics in H-J. Increase of device capability should increase the range of joint research. One specific request to TJ-II and H-J was to perform deuterium (D) experiment to increase the database (in addition to previous D-experiment in W7-AS) to resolve isotope effect, which should be critical issue to prospect burning S-H plasmas.

The topics discussed are the following: RMP (resonant magnetic perturbation), wall conditioning, 3D equilibrium, flow and viscosity, transport validation (energy transport: on-going, and particle transport: kick-off), Alfvén eigenmode and energetic particles, database issues, and reactor design and system code. Among these sessions, joint papers have been accepted on Alfvén eigenmode (oral, EX/5-2) and transport validation (poster, EX/P3-14) issues for the coming 24th IAEA Fusin Energy Conference (FEC) (at San Diego in Oct. 2012), and database issue (Singularization of data subgroups) for the coming EPS conference (Stockholm, Jul. 2012). One more joint paper originated from CWGM is on the magnetic island dynamics for the EPS, although the session was not set up in the CWGM10.

Brief memo on discussions in each session

RMP

The study on the transport modification due to RMP in LHD has been conducted as the joint experiment with tokamak community. It has been formulated as the task, TC-24 (along with the 3D effects on macro- and micro-structures), in the transport and confinement topical group in the ITPA. Further joint experiment is being planned in the coming 16th experiment campaign of the LHD for investigating how the amplitude of perturbation affects the

level of turbulent transport.

Wall conditioning

Summary of recycling and isotope exchange of H, D and He plasmas is reported from TJ-II Li-wall conditioning research. Wall conditioning strategy for W7-X has been considered from the experiences of other devices, such as WEGA, LHD and Tore Supra. Since ECRH is the main heating source for the 1st operation phase of W7-X, ECRH wall conditioning should be developed. For this purpose, joint experiment is proposed in LHD by utilizing its ECRH capability.

3D equilibrium

Recent progresses on 3D equilibrium studies in LHD high-beta plasmas were reviewed, focusing on how to identify 3D magnetic field structure. Identification approach by means of position of radial electric field (Er) =0 or maximum gradient of Er, originated to the positive Er generation due to opening magnetic field lines. This has been also observed in DIII-D. Identification of stochastization in plasma edge has been also tried with the heat pulse propagation technique. Necessity of rigorous numerical treatment outside the last closed flux surface (LCFS) is also pointed out for relating measurement at different Scrape Off Layer (SOL) positions and performing simulations on edge physics such as EMC3. An open question raised is how to validate the numerical modeling. As a follow-up discussion, divertor heat flux measurements in LHD was introduced, stating that the positions of measured heat flux peaks fit to those predicted from HINT2 numerical results. Such a validation study, including the identification of LCFS, was discussed to be formulated as joint experiments.

Flow and Viscosity

There have been recognized that range of research on plasma flow and viscosity issues has been conducted in S-H devices. Based on individual discussions made in the last 18th International Stellarator-Heliotron Workshop (Australia, 2012), it was agreed to launch the flow and viscosity session in CWGM. The possible joint actions discussed so far between NIFS and CIEMAT were introduced, such as the numerical code verification/validation and joint experiments on plasma biasing. The HSX also joined discussions with their Reynolds stress and Er measurement, and comparisons to PENTA code calculations. The proposed joint actions will be transferred to HSX group to formulate further programmatic joint actions and to set a specific goal. The topics-oriented joint actions such as on the trigger and dynamics of the L-H transition, 3D effects on zonal flow, and the impact of self-regulation mechanisms in transport and stability were also proposed in close link to “3D physics” session in ITPA.

Transport validation (energy transport)

Transport in S-H plasmas consists of neoclassical and turbulent contribution. To perform studies of transport model validation, impact of neoclassical transport has been investigated in ion-root plasmas (medium to high density with comparable electron and ion temperature under sufficient ion heating power) of W7-AS (previous documentation), LHD and TJ-II (new joint experiment). This is a natural consequent extension of joint efforts on CERC (Core Electron-Root Confinement) plasmas, and successfully documented international benchmarking activities of neoclassical transport codes. Towards joint paper in the coming IAEA-FEC, progress of energy balance analysis was shared and the formats of materials were discussed along with “homework” assignments. It was also followed up by showing examples of non-local neoclassical transport code, FORTEC-3D, to provide quantitatively different prediction of the neoclassical ambipolar Er at some cases. Certainly, it would be valuable to examine discharges of joint experiments by several other codes for validation points of view. The progress on XICS (X-ray Imaging Crystal Spectrometer, under collaboration between PPPL and NIFS) measurement of ion and electron temperatures was also reported, to provide profile information for the energy transport analysis. The request to perform also particle transport study was raised, and this became a natural introduction to the following session.

Particle transport

Density control is one of key issues to be comprehensively understood for considering operation in large S-H plasmas and reactors. The summary on particle transport from observations in LHD is as follows: the density profile becomes more hollow in outwardly shifted configuration/the lower the collisionality, density profile is determined not by particle fueling (NBI fueling and wall source) but from transport, neoclassical contribution is larger (smaller) for convection (diffusion), respectively, and gyro-kinetic quasi-linear analysis shows qualitative agreements of zero flux condition, indicating anomalous feature plays a role on transport. It was pointed out that the separation of core and peripheral region by investigating the penetration depth of neutral particles would be one approach to be considered for particle transport. Joint experiment in LHD was proposed to further investigate particle transport by decoupling heating and particle sources such as by ECRH and/or pellet injection. A summary of methods and results for particle transport

studies in TJ-II contributed to this new topic. A poor particle confinement regime is identified in low density plasmas considerably affected by kinetic effects from the ECRH. This identification must be discerned in order to plan a joint contribution. NBI plasma studies are on-going, but the analysis done so far point to a linear dependence of particle confinement time with density. There seems to be, however, a strong degradation with heating power. There is improvement of particle confinement when the L-H transition occurs, but no steady state H-mode is available to make a quantitative description.

Alfvén eigenmodes, energetic particles

This is the 3rd sessions on this topic, after the launch at 8th CWGM (NIFS, Mar. 2011). Joint experiment has been successfully evolved between H-J (low rotational transform, ι) and TJ-II (high-ι) to commonly understand Alfvén eigenmodes in low-shear S-H plasmas, to be reported as the joint paper in the coming IAEA-FEC. Comparative study will be expanded to LHD. So far, independent database in each device has been utilized for numerical code validation, along with the on-going code verification among several codes. It was pointed out that the accuracy of equilibrium, especially the ι-profile, should be carefully considered such as for ι-scan experiments and those interpretations by numerical codes. The Bernstein-wave heated plasmas in WEGA stellarator was also reported to show the existence of supra-thermal electrons in keV-range, and also to show the direct momentum transfer with a combination of 2.45 GHz ECRH.

Database issues

ISS04 has been established based on the International Stellarator-Heliotron Confinement Database (ISH-CDB) from existing devices. As the next step, the assessment of energy confinement for the future devices has been tried with utilizing the dimensionless variables following the principles of similarity and scale invariance. Clustering of database by using several sets of dimensionless variables has been going on, and still a lot of efforts will be required at this moment. Extension of CDB with new data was requested to increase the capability for discriminating dataset. The progress of Profile Database (ISH-PDB) was also reported. Equilibrium information corresponding to registered discharges, such as wout and input files of VMEC2000, has been registered (requiring authentication as joint analysis). The reading routine will be provided to cover possible different version of VMEC2000 (currently, equilibria from version 6.90 and 8.00 coexist in the database). This “de facto standard” platform should enhance the validation activity of numerical codes/modeling by easing the possible difficulties for their applications to experimental data.

Reactor, system code

One of long-term goal of the CWGM activity is to define data basis for S-H reactor studies. Thus, it is meaningful for CWGM activity to share the current status and future prospects of S-H reactor scenario and system code development to consider the research direction. In the 4th CWGM (CIEMAT, Oct. 2008), the reactor session was held, focusing on engineering issues. At this time in 10th CWGM, reactor system code application to reactor design is also emphasized. European fusion roadmap being discussed was introduced with identifying required steps towards DEMO and commercial fusion power plant (“step ladder” consideration). Design status of HELIAS 5-B (a 5-period HELIAS reactor) was reported with emphasis on engineering issues. Predictive simulation using 1D transport models (including neoclassical database and anomalous modeling) has been performed for a “up-scaled” W7-X, to particularly find the renormalization factor (in ISS04 scaling) tends to decrease with size of the plasma. This finding provides impact for taking the confinement scaling law into the system code The application of reactor system code, HELIOSCOPE, and the current status/future prospects of FFHR-d1 (heliotron reactor in the design study) was also reported. The HELIOSCOPE has been utilized to specify design window with several engineering and physics (basically scaling law, right now) conditions. Fast-time and accurate employment such as of 3D equilibrium and physics models into the system code are to be pursued to obtain more robust design. It was discussed that the interaction between system code development/application and CWGM activity in this regard should be enhanced. The optimization research of TJ-II configuration has been conducted utilizing DAB (Distributed Asynchronous Bees” algorithm on the grid computers (http://fusion.bifi.unizar.es/).

Programmatic joint experiments/activities were formulated based on discussions made in the meeting.

Finally, it should be mentioned that the next 11th CWGM was agreed to be hosted by CIEMAT. The details will be announced once they become available.

The presented materials in previous CWGMs (except the 1st one, unfortunately) can be reachable through either IPP or NIFS CWGM website (designated at the top of this manuscript). Looking back contents discussed in previous CWGMs should be instructive to consider future direction for this activity.

Acknowledgements:

Prof.R.Wolf, Dr.A.Dinklage and Ms.M.Radau (IPP-Greifswald) are greatly appreciated for their extensive efforts for hosting the 10th CWGM. Mr.R.Klatt (IPP-Greifswald) and Dr.T.Akiyama (NIFS) are also appreciated for their kind supports to make the video-conference smoothly run. The 10th CWGM is partly supported by NIFS (National Institute for Fusion Science)/NINS (National Institutes of Natural Sciences) under the project, "Promotion of the International Collaborative Research Network Formation".

3. Australia

3.1 International Collaboration in 2012

The Australian Plasma Fusion Research Facility at the Australian National University houses the H-1 heliac and the MAGPIE linear device. H-1 is a three-period helical axis stellarator with a flexible magnetic topology that allows fundamental studies in plasma confinement and stability, turbulence and flows, and confinement transitions at moderate heating power. Because of its coil-in-tank construction, the device is an ideal test bed for the development of advanced active and passive imaging diagnostic technologies from microwave through to optical frequencies.

In 2012, the new 2x200kW 4-20MHz RF heating system, including a cooled antenna was commissioned and began regular operation, as a major part of the ~US$7M upgrade under the Australian Government's Super Science Scheme. Enhancements to the Facility will enable future growth of Australian capability in fusion science and engineering, and as a focus for collaboration within the Australian community, will support the development of world-class diagnostic systems for application to international facilities in preparation for ITER.

Diagnostic upgrades completed this year included the first 7 channels of a sensitive imaging multichannel interferometer, and an imaging optical impurity monitor. This interferometer and the rf upgrades enabled magnetic field scans with minimal variation to the rf heating mechanism to investigate the scaling of the dispersion properties of the observed MHD modes.

Vacuum enhancements installed this year include the first set of three glow discharge cleaning electrodes, a new coiling cool for the high capacity cryopump, and a residual gas analyser capable of monitoring both higher pressure glow discharge cleaning, and lower pressure plasma operations.

As part of a longer term strategy that aims for an Australian involvement with ITER, upgrade funding is supporting the development of a small linear, high power-density satellite device "MAGPIE", utilizing the H-1 heating, power and diagnostic systems. This is the first device in the Materials Diagnostic Facility, led by Dr.Cormac Corr and was developed in collaboration with Oak Ridge and the Australian Nuclear Science and Technology Organisation (ANSTO), to facilitate development of diagnostics for plasma wall interactions and for characterizing advanced high temperature materials. In 2012, operation up to $10^{19}m^{-3}$ in helium and hydrogen was achieved, and some tungsten and carbon materials were exposed to the plasma.

In mid-2012 Dr Clive Michael returned to Australia to support international collaborative activities in advanced diagnostic systems and to contribute to the H-1 program, and Dr.Greg von Nessi commenced a joint appointment with the Toroidal and Plasma Theory and Modelling Groups.

- **Multilateral Collaborations**

Work on the international collaboration on MHD and configuration studies under the IEA agreement focussed on application of the new version of the data mining analysis to recent configuration scans in Heliotron-J and extensive scans in H-1, combining two poloidal arrays and the new 16 element, 3 axis helical arrays. Results were presented at the International Stellarator/Heliotron Workshop, the 22nd International Toki Conference, and the Japan Australia Diagnostic Workshop.

One and two-dimensional coherence imaging (CI) systems developed by Prof Howard at ANU underpin collaborations with the USA, EU members, which are supported by international agencies and the Australian Government. These include

- (EU) Coherence imaging systems are being installed on the ASDEX-U upgrade for imaging motional Stark effect measurements commencing January 2013. A system is also being deployed on the MAST tokamak for divertor flow and temperature imaging.

- (US) With LLNL and General Atomics, application of Doppler CI systems for imaging flows in the DIII-D divertor and scrape-off-layer. These static systems utilise novel spatial-heterodyne interferometric techniques to capture the 2-D Doppler information.

Collaboration between ANU, MPIPP (J.Svensson), and the Culham Centre for Fusion Energy (L.C.Appel) have

complementary stellarator and compact toroidal components. The project, which was supported by an Australian International Science Linkages grant, aims to develop Bayesian techniques for the integration of various diagnostic data, building on pioneering development of the technique on W7-AS. 2012 publications included evidence based cross-validation, to remove rogue diagnostic data, Thomson Scattering and a split-observation Bayesian force balance validation tool developed and implemented on MAST. During a collaborative visit to CCFE, Dr von Nessi installed a stand-alone version of the Bayesian inference code on the MAST scheduler for routine data analysis. With the addition of Dr Clive Michael to the ANU staff, an expert in fast ion plasma diagnostics, a wider collaboration was initiated between the ANU and CCFE in the modelling of Fast Ion D-alpha diagnostic using a Bayesian model.

In an application to H-1, Dr von Nessi began developing forward models for He line ratios, for application in a Bayesian inference framework.

MRXMHD: Significant progress was demonstrated in collaboration between the ANU (R.Dewar, M.Hole, B.Blackwell, M.McGann, A.Gibson, G.VonNessi), Princeton PPL (S.Hudson), RFX-mod (Dr Dominique Escande) and CCFE (Prof.Richard Dendy) on the development of a new variational principle - multi region relaxed MHD (MRXMHD). In 2012 Dr Hudson spent 3 weeks at the ANU guiding numerical studies using the new MRXMHD code SPEC. This included explanation of the spontaneous formation of a second helical axis in the RFP, which is observed at higher plasma current. This plasma is in a lower energy state than the comparable axis-symmetric case. A stability analysis showed that the formation of a second helical axis occurred via tearing modes.

In 2012, seminal "reference" publications will appear for the SPEC code, which was developed for application to stellarators. In addition to the application to RFX-mod, the code has also been applied to DIII-D plasmas with a STELLOPT field reconstruction, demonstrating the appearance of magnetic islands in pressure-flattened regions, as well as ITER with a perturbed plasma boundary. ANU student Ashley Gibson completed a Master's thesis on the mathematics underpinning MRXMHD, reconciling almost-invariant tori (imperfect magnetic surfaces) produced by the quadratic-flux-minimizing (QFMIN) surface method and the action-gradient-based ghost surface method. Results from these collaborations were presented at the invited talks by S.Hudson, M.J.Hole at the ISHW/APPTC 2012 meeting, and by M.J.Hole at contributed oral talk at the Toki 2012 meeting. Finally, with the commencement of PhD student Craig Bowie, the collaboration widened to include the modelling of ELMs as an MRXMHD avalanche.

- **Collaborations with EU**

An existing collaboration between C.Nührenberg and A.Koenies of MPIPP Greifswald, J.Bertram, R.Dewar, B.Blackwell, S.Haskey, J.Howard, M.McGann, G.Von Nessi, M.Fitzgerald and M.Hole of the ANU, which involves comparing the experimental observations of MHD activity with eigenvalue calculations using the CAS3D code and the wave-particle interaction code CAS3D-K, was expanded to commence work on continuum damping in 3D. In 2012, George Bowden commenced a PhD on this topic. A visit of A.Koenies to the ANU is planned for early 2013, as funded by a successful DAAD grant between the Group of Eight research intensive Australian Universities and German Academic Exchange Service.

Collaboration between CCFE (S.Sharapov, K.M^{C}Clements, S.Pinches, L.C.Appel) and the ANU (M. Hole, R. Dewar) in burning plasma physics, aim to non-perturbatively model the effect of energetic particles such as fusion alpha-particles on the equilibrium, wave-mode structure, and wave-mode induced confinement loss. In 2011-2012 Dr Michael Fitzgerald's work focussed on the calculation of anisotropy in MAST plasmas, and computing the impact of rotation in high beta plasmas. This new code, EFIT TENSOR, was completed in 2012, and is now being integrated into routine magnetic reconstruction tools for both MAST and JET. The impact of anisotropy-induced q profile corrections to thermal modes of the plasma was also studied. The collaboration with CCFE was also broadened to study the correlation of neutron loss with magnetic activity (Masters student, Sebastien Cox), as well as the implementation of anisotropic corrections to MHD stability codes CSCAS and MISHKA (PhD student Zhisong Qu).

- **Collaborations with JAPAN**

Multilateral data mining collaboration

- **Collaborations with USA**

In addition to the multilateral MRXMHD collaboration, and the DIII-D divertor studies the following were active in 2012:

1) ANU and R.Goulding, J.Harris and P.Krstic of ORNL: development of the Materials Diagnostic Facility Prototype and ANU, and proposals for collaborative grants.
2) ANU, PPPL and DIIID – The effect of 3D magnetic perturbations on the edge plasma.
3) ANU and B.Breizman, Univ. of Texas, Austin, and G.

Chen of ORNL in helicon waves with the electromagnetic wave code EMS, as well as the formation of gaps and gap modes in a periodic linear machine.

- **Workshops and Conferences**

The ANU hosted the combined Joint 18th International Stellarator/Heliotron Workshop (Chair: Dr.Blackwell) and 10th Asia Pacific Plasma Theory Conference (Chair: Dr.Hole) at the Australian National University in Canberra and Murramarang Beachfront Nature Reserve between Jan. 29 – Feb. 3, 2012. The combined meeting (PLASMA2012) was held in cooperation with the International Atomic Energy Agency. The purpose of the combined meetings was to provide a forum for the discussion and dissemination of research in the field of helical fusion magnetic confinement, thereby bridging stellarator and tokamak communities, and foster Asia-Pacific regional collaboration in theory and modelling. The conference, which attracted over 120 abstracts from scientists drawn from 11 nations, was opened by the ANU Vice Chancellor, Prof. Ian Young. Conference topics spanned plasma physics, materials science, and fusion technology development. A dedicated session on Monday was held on materials science, enabling involvement of the wider Australian materials science community. The meeting was supported by Thomson Scientific, which supplied the H-1 transmitter, AINSE, which supported student attendance, ANSTO, which sponsored the conference dinner, the journal Plasma Physics and Controlled Fusion, which provided a student prize, and the IAEA through its technical cooperation program. A number of ABC radio interviews were held in conjunction with the event, featuring Dr Blackwell and Dr Hole.

Dr Hole represented Australia at the 51st IFRC meeting and presented research highlights and summarised progress in upgrade of H-1 and the new materials diagnostic facility of the Australian Plasma Fusion Research Facility.

3.2 Future Research Plans

Enabled by the upgrade, configuration studies will focus on expanded configuration scans and magnetic field scans of Alfvén-driven instabilities. Multi-channel plasma density and polarization interferometers and multi-channel spectroscopic detectors will provide profile information for configuration studies and mode structure of Alfvénic instabilities. The original H-1 RF antenna will be made available for the excitation of Alfvén modes, and application of perturbation fields.

International collaboration on CI optical systems for spectro-polarimetric imaging will continue in 2012 and beyond. In the coming year, this work will embrace the following activities:

Following successful first data, a second Doppler imaging camera is planned for wide field of view divertor flow and temperature tomography on DIII-D.

Combined with fast, gated CCD cameras, newly developed passive spatial heterodyne CI systems will be deployed for synchronous detection of velocity distribution function perturbations associated with magnetic fluctuations in the H-1 heliac.

In future years we hope to deploy CI imaging systems for edge physics studies in the W7-X stellarator. The recent success of Doppler imaging on the DIII-D tokamak divertor is a valuable guide in future planning.

We are developing multiple-carrier spatial heterodyne CI systems that should allow extended capability for imaging of more complex spectral scenes and exploring Zeeman-assisted Doppler tomography of inhomogeneous magnetized plasma such as the tokamak divertor.

Utilizing the planned linear satellite device, we aim to trial imaging Stark effect and some new concepts in optical radar-based range sensing with the ultimate goal (subject to appropriate funding) to develop a prototype imager for monitoring tile erosion in high power fusion devices.

The expanded collaboration on the MRXMHD project will apply the MRXMHD code SPEC to MAST with an RMP field, and investigate control of magnetic surfaces between different relaxed regions via external coils. In 2012 the burning plasma project will focus on computing the impact of anisotropy on global modes. A reciprocal visit from IPP to Australia is also funded to implement kinetic code CKA/EUTERPE on H-1 plasmas, and develop tools to compute continuum damping in 3D.

The Australian Heliac program at the ANU has produced several technological spin-offs that are now attracting support independent of the fusion program. These include technology for long distance, non-line-of-sight VHF digital wireless communications in rural Australia (the BushLAN project), and optical coherence imaging (CI) spectroscopy systems for use in process control in steel production. A demonstration of new wireless communications technology to potential investors is near completion and has attracted interest from several quarters.

Finally, the Australian fusion science community will

continue endeavours to secure funding to develop prototype diagnostic concepts using the new capabilities of the H-1 facility for one or more plasma diagnostics for ITER. The Australian fusion science community has revising the 2007 fusion science strategic plan, taking into account funding developments over the last five years and changes to research funding schemes. We anticipate that this will be released in early 2013.

4. EU

4.1 Germany

4.1.1 International Collaborations in 2012

- **Collaborations with EU**

1) J.Belloso (CIEMAT) to IPP, 15.01. – 29.02.2012
2) S.Newton (Culham Science Centre) to IPP, 16.01. – 20.01.2012
3) P.Helander (IPP Greifswald) visited Nancy University, 26.01. – 28.01.2012
4) P.Helander (IPP Greifswald) visited Cadarache, 09.02. – 13.02.2012
5) J.Andersson (Chalmers Göteborg) to IPP, 12.02. – 18.02.2012
6) N.Marushchenko (IPP Greifswald) visited Culham Science Centre, 20.02. – 24.02.2012
7) T.Szabolics (KFKI Budapest, Hungary) to IPP, 20.02.-02.03.2012
8) J.Svensson (IPP Greifswald) visited Culham Centre for Fusion Energy, Culham, 24.02. – 23.04.2012
9) W.Schneider (IPP Greifswald) visited Culham Centre for Fusion Energy, Culham, 05.03. – 14.03.2012
10) R.Sanchez, V. Tribaldos and L. Garcia (University Carlos 3 Madrid) to IPP, 08.03. – 10.03.2012
11) T.Klinger (IPP Greifswald) to IPPLM-Council-Meeting Warsaw, 12.03. – 16.03.2012
12) A.Rodatos (IPP Greifswald) visited CEA, Cadarache, France, 12.03. - 24.03.2012
13) C.Beidler (IPP Greifswald) with EFDA: Power Plant Physics and Technology (Organisational Meeting) , Garching: 20.03.2012
14) I.Ksiazek (Opole University, Opole) to IPP, 27.03. - 30.03.2012
15) I.Ksiazek (Opole University, Opole) to IPP, 16.03. - 24.04.2012
16) J.Romero (CIEMAT, Madrid) to IPP, 06.05. – 12.05.2012
17) N.Marushchenko (IPP Greifswald) visited TU Eindhoven, 06.05. – 10.05.2012
18) A.Czermak, B. Sowicki (Polish Academy of Sciences, Cracow) to IPP, 28.05.-02.06.2012
19) I.Ksiazek (Opole University) to IPP, 28.05.-02.06.2012
20) J.L.Velasco (CIEMAT Madrid) to IPP, 29.05. – 09.06.2012
21) C.Beidler (IPP Greifswald) with EFDA: Kick-off-Meeting for “Stellarator Engineering Scoping Studies”, VC mit EFDA Garching, 13.06.2012
22) A.Mishchenko, G. Plunk (IPP Greifswald) visited CIEMAT, 17.06. – 22.06.2012
23) T.Wauters (Laboratory for Plasma Physics – ERM/KMS, Brussels) to IPP, 18.06. - 20.06.2012
24) Y.Kazakov (Chalmers University, Göteborg) to IPP, 19.06. – 22.06.2012
25) S.Kasilov (TU Graz) to IPP, 01.07. – 31.07.2012
26) N.Marushchenko (IPP Greifswald) visited KTH Stockholm, 09.07. – 15.07.2012
27) T.Ilkei (Hungarian Academy of Sciences, Budapest) to IPP, 30.07.-10.08.2012
28) P.Monreal Gonzalez (CIEMAT Madrid) to IPP, 05.08. – 18.08.2012
29) J.Gunn (CEA, Cadarache) to IPP, 06.08. - 08.08.2012
30) M.Lilley (Imperial College, London) to IPP, 29.08.2012
31) P.Urlings (University of Technology, Eindhoven) to IPP, 03.09. – 30.11.2012
32) T.Stoltzfus-Dueck (IPP Greifswald) visited CRPP Lausanne, 10.09. – 13.09.2012
33) G.Plunk (IPP Greifswald) visited Instituto de Plasmas e Fusao Nuclear Lisbon, 11.09. – 15.09.2012
34) P.Helander (IPP Greifswald) visited DTU Risø, 12.09. – 13.09.2012
35) J.Connor (Culham Science Centre) to IPP, 16.09. – 28.09.2012
36) C.Beidler (IPP Greifswald) with EFDA: Progress Report “Stellarator Engineering Scoping Studies”, VC mit EFDA Garching, 20.09.2012
37) J.Svensson (IPP Greifswald) visited Culham Centre for Fusion Energy, Culham, 21.09. – 22.12.2012
38) P.Helander (IPP Greifswald) visited Culham Science Centre and Oxford University, 28.09. – 13.10.2012
39) J.M.Garcia Regaña (IPP Greifswald) visited CRPP Lausanne, 30.09. – 07.10.2012
40) T.Wauters (Laboratory for Plasma Physics – ERM/KMS, Brussels) to IPP, 07.10. – 20.10.2012
41) H.Oosterbeek (University of Technology, Eindhoven) to IPP, 31.10. – 03.11.2012
42) A.Rodatos (IPP Greifswald) visited CEA, Cadarache, France, 05.11.-07.12.2012
43) J.Baldzuhn, (IPP Greifswald) visited CEA, Cadarache, France, 07.11. - 10.11.2012
44) C.Beidler (IPP Greifswald) with EFDA: Final Report “Stellarator Engineering Scoping Studies”, IPP Greifswald, 22.11.2012
45) T.Ilkei, G.Kocsis (Hungarian Academy of Sciences, Budapest) to IPP, 03.12. - 07.12.2012
46) P.Helander (IPP Greifswald) visited CRPP Lausanne, 05.12. – 07.12.2012

- **Collaborations with Japan**

1) G.Kawamura (NIFS) to IPP Greifswald,

18.01.–28.01.2012
2) A.Kus (IPP Greifswald) visited NIFS, 10.03.–30.03.2012
3) Y.Suzuki (NIFS) to IPP Greifswald, 11.03. –14.03.2012
4) M.Yokoyama (NIFS) to IPP Greifswald, 28.05.–15.06.2012
5) G.Kawamura (NIFS) to IPP Greifswald, 28.05.–02.06.2012
6) O.Grulke (IPP Greifswald) to NIFS, Toki, 16.07.–19.10.2012
7) M.Jakubowski (IPP Greifswald) visited NIFS, Toki,21.10.2012
8) G.Kawamura (NIFS) to IPP Greifswald, 28.10. –02.11.2012
9) Y. Todo (NIFS) to IPP Greifswald, 31.10. – 10.11.2012
10) M.Krychowiak, E.Winkler (IPP Greifswald) visited NIFS, 05.11. – 16.11.2012
11) J.Geiger (IPP Greifswald) visited NIFS, 10.11.–24.11.2012
12) T.Klinger (IPP Greifswald) visited NIFS, 30.11.–03.12.2012

- **Collaborations with Russia**

1) K.Dyabilin (Kurchatov Institute Moscow) to IPP Greifswald, 29.01. – 26.02.2012
2) M.Isaev (Kurchatov Institute Moscow) to IPP Greifswald, 29.01. – 11.02.2012
3) M.Mikhailov (Kurchatov Institute Moscow) to IPP Greifswald, 27.02. – 26.04.2012
4) T.Richert, J.Baldzuhn (IPP Greifswald) and T.Franke (IPP Garching) visited Budker Institute Novosibirsk, 16.06. – 20.06.2012
5) T.Richert (IPP Greifswald) visited Budker Institute Novosibirsk 11.09. – 27.09.2012
6) M.Mikhailov (Kurchatov Institute Moscow) to IPP Greifswald, 22.10. – 14.12.2012
7) N.Marushchenko (IPP Greifswald) visited IOFFE Institute St. Petersburg, 30.10. – 02.11.2012

- **Collaborations with USA**

1) P.Helander (IPP Greifswald) visited MIT Boston, 09.01. – 13.01.2012
2) O.Grulke (IPP Greifswald) visited PSFC/MIT, Boston, 04.02. – 13.02.2012
3) X.Sarasola Martin (IPP Greifswald) visited Columbia University, New York, 18.02.-18.03.2012
4) O.Grulke, T.Klinger (IPP Greifswald) to Kick-off-Meeting MPRC Princeton, 27.03. – 30.03.2012
5) P.Helander (IPP Greifswald) visited Princeton Plasma Physics Laboratory, 27.03. – 31.03.2012
6) G.Wurden (Los Alamos Energy Sciences, Los Alamos) to IPP, 20.05.-02.06.2012
7) J.Harris, D.Gates (Princeton Plasma Physics Laboratory, Princeton) to IPP Greifswald, 08.07. – 20.07.2012
8) A.Bader (University of Wisconsin) to IPP Greifswald, 29.07. – 10.08.2012
9) D.Mikkelsen (Princeton Plasma Physics Laboratory) to IPP Greifswald, 12.09. – 22.09.2012
10) H.Smith (IPP Greifswald) visited Princeton Plasma Physics Laboratory, 14.10. – 27.10.2012
11) T.Sunn Pedersen (IPP Greifswald) visited Columbia University, New York, 02.11. - 06.11.2012
12) X.Sarasola Martin (IPP Greifswald) visited Columbia University, New York, 01.12. - 15.12.2012

- **Conference participation**

1) M.Hirsch: ESTRELL Workshop, 26.01 - 27.01.2012, Nancy, France
2) M.Drevlak, O. Ford, J. Geiger, T. Klinger, H. P. Laqua, T.Sunn Pedersen, R. C. Wolf: 18th International Stellarator/Heliotron Workshop, 29.01. – 03.02.2012, Canberra, Australia
3) G. Kuehner: Software Engineering Conference, 27.02. – 02.03.2012, Berlin, Germany
4) H.Bohlin, M.Drevlak, P.Drewelow, T.Klinger, H.P.Laqua, M.Otte, J.Proll, H.Smith, A. von Stechow, T.Sunn Pedersen, O.Zacharias: DPG-Fruehjahrstagung, 11.03. – 16.03.2012, Stuttgart, Germany
5) T.Bird, P.Helander, A.Mishchenko, G.Plunk and J.Proll: Workshop „Gyrokinetics for ITER“, 18.03. – 23.03.2012, Vienna, Austria
6) X.Sarasola Martin, T.Sunn Pedersen: International Workshop on Positrons in Astrophysics, 19.03. - 23.03.2012, Mürren, Switzerland
7) A.Werner: Smart Systems Integration, 21.03. – 22.03.2012, Zurich, Switzerland
8) A.Dinklage: 7th International Validation Workshop on Data Processing, Analysis and Validation, 26.03. – 28.03.2012, Frascati, Italy
9) J.M.Garcia Regaña: Sherwood Conference, 31.03. – 03.04.2012, Atlanta, USA
10) R.König: 19th Topical Conference High Temperature Plasma Diagnostics, 06.05. – 10.05.2012, Monterey, CA, USA
11) V.Erckmann: 17th Joint Workshop on Electron Cyclotron Emission and Electron Cyclotron Resonance Heating,07.05.– 10.05.2012, Deurne, The Netherlands
12) Y.Feng, M.Laux, S.Marsen: 20th International Conference on Plasma Surface Interactions, 21.05. – 25.05.2012, Aachen, Germany
13) J.Schacht: 18th Real Time Conference, 09.06. – 15.06.2012 Berkeley, USA
14) H.P.Laqua: 24th Joint Russian-German Meeting on ECRH and Gyrotrons, 10.06. – 16.06.2012, Nizhny Novgorod, Russia
15) A.Rodatos, E. Winkler: 11th Kudowa Summer School, Kudowa Zdróy, 11.06. - 15.06.2012
16) H.Bohlin, P.Drewelow, P.Helander, T.Klinger, P.Kornejew, A.Kus, S.Schmuck, W.Schneider, X.Sarasola Martin, A.von Stechow, T.Sunn Pedersen, H.Thomsen, D.Zhang: 39th European Physical Society Conference on Plasma Physics, 02.07. – 06.07.2012, Stockholm, Sweden

17) M.Borchardt and R.Kleiber: Workshop "Algorithms, Performance and Accuracy in Gyrokinetic Codes", 22.08. – 24.08.2012, Warwick, GB
18) T.Bird, J.M.Garcia Regaña, C.Nührenberg, J.Proll and O.Zacharias: Joint Varenna – Lausanne International Workshop, 27.08. – 31.08.2012, Varenna, Italy
19) C.Biedermann, X.Sarasola Martin, E.Stenson, T.Sunn Pedersen: 10th International Workshop on Non-neutral Plasmas, 27.-30.08.2012, Greifswald, Germany
20) N.Marushchenko: International Conference and School on Plasma Physics and Controlled Fusion, 17.09. – 22.09.2012, Alushta, Ukraine
21) A.Cardella, K.Grosser, D.Hathiramani, T.Klinger, P.McNeely, G.Michel, M.Schülke, S.Thiel: 27th Symposium on Fusion Technology, 23.09. – 28.09.2012, Liège, Belgium
22) A.Dinklage, M.Hirsch, M.Jakubowski, R.Kleiber, A.Könies, R.C.Wolf: 24th IAEA Fusion Energy Conference, 08.10. – 13.10.2012, San Diego, USA
23) R.C.Wolf: 1st IAEA DEMO Programme Workshop, 15.10. – 18.10.2012, Los Angeles, USA
24) P.Kempkes, B.Buttenschön: AWAKE Collaboration Meeting, 17.10. – 19.10.2012, Cern
25) T.Sunn Pedersen: 54. Annual Meeting of the APS Division of Plasma Physics, 29.10.-02.11.2012, Providence, Rhode Island, USA
26) H.Hölbe, Ringberg Theory Meeting, 05.11. - 09.11.2012, Ringberg, Germany
27) Y.Feng: 20th European Fusion Physics Workshop, 03.12. – 05.12.2012, Ericeira, Portugal

4.1.2 Participation in Joint Projects

- **International stellarator/heliotron confinement data base**

EU-US Transport Task Force and EFDA Transport Topical Group Meeting: Padova, Italy, 03.09. – 06.09.2012, T. Bird

- **International stellarator/heliotron profile data base**

Contributions from A.Dinklage, A.Kus, C.Beidler, H.Maaßberg, S.Marsen

- **ITPA diagnostics**

Contributions from R.König: 14.05.-17.05.2012, Moscow, Russia

- **ITPA confinement and transport**

Contributions from M. Jakubowski, A. Dinklage chairs the 3D working group within the ITPA Transport and Confinement group.

- **ITPA edge and pedestal**

Contributions from M. Hirsch

- **ITPA Fast Particles**

A.Könies: ITPA Energetic Particles Topical Group Meeting, 05.03. – 09.03.2012, NIFS, Japan

A.Könies: 9th ITPA Energetic Particles Topical Group Meeting, 15.10. – 17.10.2012, San Diego, USA

4.1.3 Plans for 2013

- **Planning stellarator/heliotron theory**

1) J.Geiger plans to go to NIFS to work on 3D MHD equilibrium problems.
2) A.Könies plans to participate in the ITPA meetings on Fast Particles in Culham.
3) T.Bird and J.Proll plan to visit the Wolgang-Pauli-Institute in Vienna to work on gyrokinetics.
4) N.Marushchenko plans to visit Culham and Graz to work on heating and current drive.
5) T.Stoltzfus-Dueck plans to visit Lausanne to suggest rotation experiments on TCV.
6) A.Mishchenko plans to attend the Festival of Theory in Aix-en-Provence.
7) A.Runov plans to visit Kharkov to work on Monte Carlo Methods.
8) J.Proll plans to visit Culham to work on Microinstabilities in Stellarators.

- **Spectroscopic diagnostics**

1) R.Burhenn (IPP Greifswald) plans several visits to TEXTOR (FZJ) for transferring the HEXOS spectrometer to W7-X.
2) I.Ksiazek (Institute of Physics, Opole University, Opole) plans several visits (each about 1-2 weeks) to IPP Greifswald in the frame of the cooperation concerning the development of the C/O-monitor diagnostic for W7-X.
3) A.Czermak (Institute of Nuclear Physics PAN, Cracow) plans a visit to IPP Greifswald for the acceptance test of the prototype detectors for the W7-X C/O monitor.
4) M.Krychowiak plans a visit to Tore Supra (CEA) for tests of spectroscopy in-situ monitoring of vacuum windows coatings during long-pulse discharge

- **IR/visible Imaging Diagnostics**

A.Rodatos plans several visits to Tore Supra (CEA) for software development for hot spot detection and image scene understanding within a common framework as part of the EFDA GOT WP10 "Imaging for Fusion".

- **Collaboration with NIFS**

1) A.Dinklage plans to visit NIFS for particle transport experiments (2 weeks)

- **Neutron diagnostics**

1) Mutual visits (about 1-2 per year, each about for 2-3 days) in the frame of collaboration with PTB Braunschweig on the neutron counter system for W7-X are planned to discuss the progress and the work plan of the project (involving R.Burhenn, R.König, W.Schneider). In addition, W.Schneider will visit PTB Braunschweig (about 6-8 times per year for 1 to 2 weeks) to engage in development of neutron monitoring systems and in MCNP calculations.

- **Microwave diagnostics**

1) H.Oosterbeek (Technical University of Eindhoven) + student(s) will visit IPP: Measurement of the power flux density in a microwave stray radiation field

- **International stellarator/heliotron profile data base**

1) A.Kus plans to visit NIFS within the stellarator-heliotron database cooperation (3 weeks)
2) A.Kus plans to visit CIEMAT within the stellarator-heliotron database cooperation (2 weeks)
3) A.Dinklage plans to attend the CWGM (Madrid, Spring 2013)

- **ITPA confinement and transport**

1) M.Jakubowski and A.Dinklage plan to attend the ITPA T&C meetings (spring/fall). Dinklage chairs the 3D working group within the ITPA Transport and Confinement group.

- **Collaboration on ECRH, ECCD and ECE Plans 2013**

1) H.Laqua , T.Stange, M.Otte and M.Preynas will visit Kyoto University (Heliotron-E) and NIFS (LHD) for the Joint research program “Optimization of high power ECRH application to helical fusion plasma confinement systems” subject to support by DAAD-JSPS
2) K.Nagasaki, K.Hada (Kyoto University) will visit Greifswald for the Joint research program “Optimization of high power ECRH application to helical fusion plasma confinement systems” subject to support by DAAD-JSPS

- **Conference participation 2013**

1) P.McNeely: Workshop "Frontiers in Low-Temperature Plasma Diagnostics", 09.05. – 12.05.2013, Greifswald, Germany
2) A.Werner: 25th Symposium On Fusion Engineering (SOFE25), 10.06. – 14.06., San Francisco, USA
3) N.Rust: 40th International Conference on Plasma Science (ICOPS-40), 16.06. – 22.06.2013, San Francisco, USA
4) S.Bozhenkov: 40th European Physical Society Conference on Plasma Physics (EPS-40), 01.07. – 05.07.2013, Espoo, Finland
5) H.Braune, G.Michel: 38th International Conference on Infrared, Millimeter, and Terahertz Waves, 01.09. – 07.09.2013, Mainz, Germany
6) P.McNeely: 15th International Conference on Ion Sources, 09.09. – 13.09.2013, Chiba, Japan
7) A.Dinklage: 8th International Validation Workshop on Data Processing, Analysis and Validation, Oct./Nov. 2012, Ghent, Belgium
8) V.Erckmann: Topical Conference on Radio Frequency Power in Plasmas

4.2 Spain

4.2.1 International Collaborations in 2012 using TJ-II at CIEMAT

- **Collaborations with Russia**

1) A.Melnikov and L. Eliseev and members of the HIBP Kurchatov Institute team were visiting CIEMAT to investigate the structure of plasma potential and plasma fluctuations in ECRH and NBI plasmas (in Lithium coated wall conditions) and measurements with two slit HIBP detector. The second HIBP system has been built for long-range (zonal flows) correlation studies and the commissioning is planned for beginning 2013.
2) Collaboration with General Physics Institute, Moscow on the characterization of the plasma reflected power on gyrotron performance. This includes preparation and installation of experimental systems in TJ-II, participation in experiments and analysis of the results. The visiting scientists of GPI involved have been: D.Malakhov (19 March-19 April and 23 October-22 December), Y.Bondar (19 March-19 April), N.Kharchev (26 April-26 May and 27 September-26 October), V.Borzosekov (26 April-26 May), E.Konchekov (27 September-26 October), K.Sarksyan (2 -16 October)

- **Collaborations in Europe**

Germany

1) C.Hidalgo was visiting IPP-Greifswald (August 20-24) to discuss the IPP-CIEMAT collaboration agreement in the field of development and operation of diagnostics and related physics evaluation for W7-X.
2) J.L.Velasco and D. López-Bruna were attending the 10^{th}-CWGM held in Greifswald June 2012
3) J.L.Velasco visited Greifswald during one week in

June 2012 to work on Neoclassical Transport Theory.

Portugal

1) Silva and I.Nedzelskiy were visiting CIEMAT to continue our collaboration on edge studies (edge turbulence and transport studies and diagnostic development including RFA and probes) during 2012.
2) D.Baião was working in her PhD thesis on soft x-ray based Te diagnostic for high density plasmas in the TJ-II stellarator (including prototypes construction, testing and measurements in TJ-II).
3) Continuing the collaboration in reflectometry in TJ-II with S. Da-Graça and L.Cupido.

Italy

1) Collaboration with M.Spolaore and the RFX-mod team to participate on edge diagnostic development and measurements in TJ-II including the design, development of electromagnetic probes and characterization of the electromagnetic nature of plasma filaments in TJ-II.
2) B.Momo was visiting CIEMAT (May) for studying transport in 3D magnetic confinement devices.

- **Collaborations with USA**

1) E.Hollmann (USCD) was visiting CIEMAT (1 week, June 2012) working on parallel / radial impurity transport studies.
2) K.McCarthy visited Oak Ridge National Laboratory (1 week, March 2012) for testing the TJ-II pellet injector, which was shipped to Ciemat in August 2012.
3) I.Calvo spent the month of September, 2012 at MIT to work on gyrokinetic theory.
4) E.R.Solano spent January 2012 in S. Diego (D-III-D) to work on MHD dynamics and transport barriers.
5) F.Tabarés was visiting PPPL to discuss plasma-wall issues on Li coating.

- **Collaborations with Ukraine**

1) The Heavy Ion Beam Probe team (led by L.Krupnik, Institute of Plasma Physics, National Science Center "Kharkov Institute of Physics and Technology", Kharkov) has been fully involved in the characterization of radial electric fields and plasma fluctuations in ECRH and NBI plasmas in the TJ-II stellarator during 2012 experimental campaign. The development of the second HIBP system has been finalized and installed (injector and analyzer) in TJ-II with on-going commissioning activities (December 2012).

- **Collaborations with Japan**

1) K.Ida and N.Tamura (NIFS) visited CIEMAT (March) to study the role of magnetic topology in the radial propagation of heat pulses and development of plasma diagnostics (TESPEL, BES)
2) M.Shoji (NIFS) visited CIEMAT (March) to work on edge diagnostics (fast cameras).
3) Y.Narushima visited CIEMAT in one week (March 2012) to work on island healing in stellarators.
4) Collaboration on fast particle physics. Joint experiments were planned in advance and performed in TJ-II on 14-15 March 2012. First analysis of the results and preliminary discussions took place on 16 March 2012. The visiting scientists involved were:
   T.Ido, NIFS,
   A.Shimizu, NIFS (12-16 March)
   M.Shibuya, Engineer of NIFS (12 March)
   T.Komoto, Engineer of NIFS (12 March)
   K.Mukai, Osaka Univ. (12-16 March)
   S.Yamamoto, Kyoto Univ. (12-16 March)
5) A.Alonso visited Kyoto University (H-J) during 5-9 March 2012, discussing the physics of plasma viscosity in stellarator devices.
6) S.Satake (NIFS) visited CIEMAT during June (11-19) to discuss comparison of neoclassical approaches (MC global and DKES local calculations) in different stellarator devices.

- **stellarator/heliotron working groups and ITPA**

The 10th Coordinated Working Group meeting (CWGM) was held Greifswald (June 2012) to discuss joint activities. Ciemat staff has participated on different topics including L-H physics, momentum transport, edge transport and fast particle physics.

CIEMAT scientists have been directly involved in the ITPA activities along 2012: E. Ascasibar was attending the ITPA Integrated Operational Scenarios meeting (Madrid April-2012, La Jolla October-20122); C.Hidalgo was attending the ITPA Transport and Confinement meetings (April-2012 Heifei; October-2012 La Jolla); F.Tabarés was attending the ITPA Scrape-off Layer and Divertor meeting (October-2012 La Jolla).

4.2.2 Plans for 2013

The main research activity of Euratom – Ciemat association will remain on concept improvement development and on the fusion technology programme with special emphasis on all the different aspects of fusion materials technology. In addition, we will strengthen and continue with our long standing tradition to extend our physics studies to different confinement concepts (tokamak / stellarators), looking for common clues as a fundamental way to investigate basic

properties of magnetic confinement beyond any particular concept.

The following research areas are foreseen in the 2013 research programme:

1) Stellarator physics: confinement data-base, neoclassical transport, stellarator optimization and magnetic configuration effects on confinement. These activities are carried out within the framework of the international stellarator implementing agreement.
2) Plasma diagnostic development and engineering: Diagnostic developments for TJ-II will continue and in a wider context for JET, ITER (reflectometry, VIS-IR spectroscopy) and W7-X (reflectormetry and zonal flow physics)
3) Plasma heating (NBI, ECRH) and their role of fast particles driven modes.
4) Physics of advanced confinement scenarios: transport barrier physics, isotope effect, impurity transport and stability (including the role of magnetic well)
5) Theory and modelling of plasma transport, stability and equilibrium with emphasis on island dynamics and breaking of nested surface topology (3-D effects) and Gyrokinetic theory.
6) Plasma – wall studies, exploring plasma-wall interaction scenarios with Li coating and Li-liquid limiter concepts.
7) Data acquisition, control and advanced data analysis techniques.

The following collaborations are planned during 2013:

- **Collaborations with Russia**

1) Continuation of the collaboration with General Physics Institute, Moscow (K.Sarksyan, N.Kharchev and GPI Team) on the characterization of the plasma reflected power on gyrotron performance.
2) S.Pavlov (Kharkov Institute of Ukraine) will visit Ciemat to work on ECRH theory.
3) S.Petrov and V.Nesenevich (IOFFE) will visit CIEMAT to participate on charge exchange spectrometry measurements.
4) A.Melnikov and L.Eliseev and members of the HIBP Kurchatov Institute team will visit CIEMAT to investigate the structure of plasma potential in ECRH and NBI plasmas (in Lithium coated wall conditions) and measurements using two HIBP systems for zonal flows experiments in the core plasma region.

- **Collaborations in Europe**

Germany

1) E.Sánchez will visit Greifswald (Germany) to work on neoclassical transport and gyrokinetic theory respectively.
2) A.Alonso, J.L.Velasco and I.Calvo will visit Greifswald to discuss ongoing impurity studies including role of poloidal asymmetries and underlying mechanisms.

Portugal

C.Silva, L.Cupido and I.Nedzelskiy will visit CIEMAT to continue our collaboration on edge studies using arrays of Langmuir probes, Retarding Field Analyzers (RFA) and reflectometry.

Italy

Collaboration with M.Spolaore and the RFX-mod team to participate on edge diagnostic development and measurements of electromagnetic turbulence in TJ-II.

- **Collaborations with USA**

1) E.Hollmann (USCD) will visit CIEMAT (June 2013) to work on impurity transport studies in TJ-II.
2) S.Combs (ORNL) and Ch. Foust might visit CIEMAT for pellet injection commissioning experiments along 2013.
3) J.L.Velasco and A.Alonso will visit Wisconsin to discuss ongoing research on role of symmetry on zonal flows and isotopic effect.
4) I.Calvo will visit MIT to work on gyrokinetic Theory development.

- **Collaborations with Ukraine**

L.Krupnik and HIBP team will visit TJ-II for investigation of the structure of radial electric fields using HIBP diagnostic (Institute of Plasma Physics, National Science Center “Kharkov Institute of Physics and Technology). The second HIBP system has been design for long-range correlation studies (zonal flows); the final injector installation and test is foreseen during 2012.

- **Collaborations with Japan**

1) Collaboration on fast particle physics with Japanese institutions will continue. Joint experiments will be performed in TJ-II on March 2013. The visiting scientists likely to be involved will be K.Nagaoka (NIFS), S.Yamamoto (Kyoto Univ.). T.Ido (NIFS) and A.Shimizu (NIFS).
2) Keep in touch activities on BES in stellarators (TJ-II).

3) Based on the TJ-II experience with the pellet injector developed by ORNL, we plan to explore the viability of TESPEL system developed by NIFS (N.Tamura et al.).
4) J.L.Velasco and A. Alonso will visit NIFS to continue our cooperative effort on neoclassical studies and viscosity analysis including comparison with experimental results.

- **International stellarator/heliotron working groups**

Ciemat staff will participate in the forthcoming CWGM and ITPA meetings to be held along 2013.

5. Japan

5.1 International Collaborations by the LHD team at NIFS

- **Collaborations with Australia**

1) T.Ido (NIFS) attended 18th International Stellarator/Heliotron Workshop & 10th Asia Pacific Plasma Theory Conference held in Canberra, Australia from 29 January to 3 February 2012 to give an invited talk entitled "Potential Fluctuations of Geodesic Acoustic Mode and Alfvén Eigenmodes Driven by Energetic Particles in the LHD Plasmas."
2) M.Yokoyama (NIFS) visited Australian National University (and Murraramang) from 26 Jan. to 4 Feb. 2012 to organize 9th CWGM, and to attend the 18th International Stellarator-Heliotron Workshop. He presented the invited talk on Transport Model Validation activity being conducted as topical collaboration in CWGM.
3) A.Wakasa (Kyoto Univ.) visited Australian National University (and Murraramang) from 26 Jan. to 4 Feb. 2012 to organize 9th Coordinated Working Group Meeting (CWGM), and to attend the 18th International Stellarator-Heliotron Workshop.
4) G.Motojima (NIFS) visited the Australian National University and Murramarang resort, Canberra, Australia to attend 18th International Stellarator/Heliotron Workshop & 10th Asia Pacific Plasma Theory Conference from 26 January to 4 February 2012 to give a poster presentation entitled "Observation of Internal Distribution in a Pellet Plasmoid by High-speed Imaging Spectroscopy ".
5) C.Suzuki (NIFS) visited Australian National University (Australia) from 27th Jan. to 3rd Feb. 2012 to join the 9th CWGM and the 18th ISHW meeting to give a presentation on the real-time magnetic coordinate mapping system in LHD.
6) H.Yamada (NIFS) visited Australian National University (and Murraramang) from 28 Jan. to 4 Feb. 2012 for Joint Stellarator-Heliotron Workshop and Asia-Pacific Plasma Theory Conference and also to attend the 40th Executive Committee Meeting of IEA Implementing Agreement on Stellarator-Heliotron Concept.
7) H.Sugama (NIFS) visited Australian National University, Canberra, and Murramarang Beachfront Nature Resort, Australia from January 28th till February 4th. He participated in the 18th International Stellarator/Heliotron Workshop and the 10th Asia Pacific Plasma Theory Conference. He made a presentation entitled "Plasma Flows and Geometric Symmetry in Toroidal Systems".
8) T.Morisaki (NIFS) visited Australia National University from Jan. 29 to Feb. 4 to participate in the 18th International Stellarator-Heliotron Workshop.

- **Collaborations with EU**

1) H.Yamada (NIFS) visited the IAEA Headquarter (Vienna, Austria) from 8 to 13 Jan. 2012, and attended the Consultancy Meeting on Strategic issues and milestones on the way to a demonstration fusion power plant.
2) G.Kawamura (NIFS) visited Max-Plank-Institut fur Plasmaphysik (Greifswald Germany) from 15 to 27 January 2012, from 27 May to 1 June 2012 and from 28 October to 2 November 2012 for collaboration on simulation modeling of LHD SOL and divertor plasmas.
3) G.Kawamura (NIFS) visited Forschungszentrum Juelich (Germany) from 28 January to 4 February 2012 and from 21 to 27 October 2012 for collaboration on modeling of plasma-wall interactions for impurity transport simulation.
4) C.S.Harte (University College Dublin, Ireland) visited NIFS (C. Suzuki) from 7th to 24th Feb. 2012 to make discussions on the analysis of EUV spectra from highly charged tungsten ions observed in LHD.
5) Y.Narushima (NIFS) visited CIEMAT from February 20th to 27th March, 2012 to join experiments regarding a magnet island dynamics.
6) R.Yasuhara (NIFS) visited Culham Science Center in England from 20 Feb. to 25 Feb. 2012 to discuss the international collaboration about the advanced Thomson scattering system for LHD and MAST.
7) H.Nakano visited IPP-Garching (Germany) from Feb. 27 to Mar. 31 to join experiments of RF negative ion source and measure negative ion density with the Cavity Ring Down spectroscopy.
8) H.Yamada (NIFS) visited Fusion 4 Energy (Munich), Max-Planck Institut für Plasmaphysik (Garching and Greifswald) for discussions on range of programmatic

collaborations from 28 Feb. to 4 Mar., 2012.

9) Gerard O'Sullivan (University College Dublin, Ireland) will visit NIFS (C. Suzuki) from 28th Feb. to 22nd Mar. 2013 for discussions on the analysis of EUV spectra from highly charged high-Z ions observed in LHD and other light sources.
10) M.Shoji (NIFS) visited to CIEMAT in Madrid, Spain from 4th to 17th March, 2012 to attend international collaboration experiments for observation of dust trajectories released from a poloidal limiter with a fast framing camera in TJ-II.
11) N.Tamura (NIFS) visited CIEMAT from March 6th to March 15th, 2012 to join experiments regarding a nonlocal heat transport.
12) G.Motojima (NIFS) visited Max Planck Institute for Plasma Physics in Garching, Germany from 25 March to 29 March 2012 to discuss the high density H-mode plasma using pellet between Tokamak and stellarator/heliotron within a framework of Erasmus Mundus Program.
13) G.Motojima (NIFS) visited Ghent University in Belgium to give presentations of "Helical systems" and "Technology progress and physics achievements in LHD" from 29 March to 1 April 2012 within a framework of Erasmus Mundus Program.
14) H.Yamada (NIFS) visited Max-Planck Institut für Plasmaphysik (Greifswald) for IPP International Scientific Advisory Board from 1 to 6, May, 2012.
15) C.Suzuki (NIFS) visited University College Dublin (Ireland) from 9th May to 3rd Jul. 2012 for a collaborative research with Prof. O'Sullivan on the laser-produced plasma experiments using lanthanide targets and the comparative analysis of the EUV spectra both from the LHD and from the laser-produced plasmas.
16) V.Antoni and G.Serianni (Consorzio RFX, Italy) visited NIFS (K. Tsumori) from Mar. 19 to Mar. 26 2012 to discuss the benchmark test of numerical codes for secondary particle trajectory and grid heat loading.
17) G.Kawamura (NIFS) visited EUROGRESS (Aachen Germany) to attend the 20th International Conference on Plasma Surface Interactions from 20 to 25 May 2012 to give a poster presentation entitled "Kinetic effects of inclined magnetic field on physical sputtering by impurity ions".
18) M.Shoji (NIFS) attended the 20th International Conference on Plasma Surface Interactions in Aachen, Germany from 21th to 25th May, 2012 in order to give a poster presentation which title is "Effect of a baffle divertor structure on neutral hydrogen and helium transport in the Large Helical Device".
19) M.Yokoyama (NIFS) visited Max-Planck Institute for Plasma Physics (Greifswald) from 27 May. to 16 Jun. 2012 to make joint analyses on transport properties of LHD, TJ-II and W7-AS plasmas towards the joint paper for the 24th IAEA Fusion Energy Conference. He also played a role as the co-chair for the 10th CWGM, held in Greifswald in 2-4 Jun. during his stay.
20) M.Kisaki (NFS) visited Consorzio RFX (Italy) from May 28 to July 6 2012 to adopt numerical codes for secondary particle trajectory and grid heat loading to LHD-NBI.
21) S.Satake (NIFS) visited IPP-Greifswald (Germany) from 6 to 9 June 2012 to attend the 10th Coordinated Working Group Meeting (CWGM 10) and present his simulation study on the relation between poloidal flow and viscosity in LHD biasing plasma. He also visited CIEMAT (Spain) from 11 to 18 June to have a kickoff discussion about inter-machine collaboration on the simulation and experimental studies on plasma flow, viscosity, and confinement among helical devices.
22) H.Sugama, T.-H.Watanabe, M.Nunami, and A.Ishizawa (NIFS) visited CIEMAT to attend the Gyrokinetic Theory Working Group Meeting from 18 June to 29 June, 2012. They presented recent theoretical and numerical simulation results on plasma flows and related turbulent transport phenomena in toroidal systems.
23) K.Ichiguchi (NIFS) visited Carlos III University (Spain) from 24 June to 1 July to discuss nonlinear MHD analysis of LHD plasmas with B.A.Carreras (BACV Solutions Inc. USA).
24) Y.Narushima (NIFS) participated 39th European Physical Society Conference on Plasma Physics held jointly with 16th International Congress on Plasma Physics in Stockholm, Sweden, 2-6 July 2012. He presented "Response of magnetic island to resonant magnetic perturbation in LHD" as a poster.
25) K.Ichiguchi (NIFS) attended 39th European Physics Society Conference on Plasma Physics & 16th International Congress on Plasma Physics, held at Stockholm Waterfront Center, (Sweden), 2-6 July 2012 to make a poster presentation entitled “MHD Simulation of Heliotron Plasma in Change of Background Field”.
26) A.Komori (NIFS) attended European Physical Society Meeting (with International Congress on Plasma Physics) (held in Stockholm) from 3 to 6, Jun., 2012.
27) T.Goto (NIFS) visited IPP Greifswald, Germany from July 5 to 8 to attend the 10th Coordinated Working Group Meeting (CWGM) and to discuss with Prof.R.C. Wolf about collaborative research on reactor design. He made a presentation titled "Development of System Design Code for Heliotron Reactors and Helical DEMO Reactor FFHR-d1" in the 10th CWGM.
28) P.Veltri (Consorzio RFX, Italy) visited NIFS

(M.Kisaki) from July 5 to Aug. 3 2012 to join the operation of LHD-NBI and benchmark numerical codes for secondary particle trajectory and grid heat loading.

29) M.Yokoyama (NIFS) attended the 1st meeting of the Japan-Spain joint committee on Cooperation in Science and Technology, held in Madrid in 12-13 Jul. 2012, and he presented the prosperous collaborative activity on fusion science and technology between CIEMAT and NIFS.
30) O.Grulke (Max-Planck Institute for Plasmaphysik, Germany) visited NIFS (T. Ido and M. Tanaka) as a guest professor from 16 July to 15 October 2012 to study turbulent transport in SOL/divertor region of the LHD plasmas.
31) C.Suzuki (NIFS) visited Max-Planck Institute for Nuclear Physics and Heidelberg University (Germany) from 29th Aug. to 7th Sep. 2012 to join the 2nd IAEA Research Coordination Meeting of the Coordinated Research Project on "Spectroscopic and Collisional Data for Tungsten from 1 eV to 20 keV" and the 16th International Conference on the Physics of Highly Charged Ions to give presentations on the analysis of EUV spectra from highly charged tungsten and lanthanide ions observed in LHD.
32) Gerard O'Sullivan (University College Dublin, Ireland) visited NIFS (C. Suzuki) from 1st to 2nd Oct. 2012 to make discussions on the analysis of EUV spectra from highly charged high-Z ions observed in LHD and other light sources
33) E.Winkler (IPP Greifswald) and M.Krychowiak (IPP Greifswald) will visit NIFS from Nov. 5 to 16 to discuss the collaboration program about development of helium beam diagnostics for the edge plasma measurements in LHD and W7-X.
34) V.Antoni and G.Serianni will visit NIFS (K. Tsumori) from Dec. 17 to Dec. 21 to discuss the benchmark test of simulation codes and experiments of negative ion beam diagnostics using the test facility in NIFS.

- **Collaborations with Russia**

1) P.Aleynikov, S.Konovalov, V.Lukash and V.D.Pustovitov (Kurchatov Institute) visited NIFS in Mar. 2012 to attend the ITPA MHD and Energetic Particles Topical Group Meeting.
2) M.Goto (NIFS) attended the International Conference on Spectral-line Profiles, held in St. Petersburg in June 2012.
3) I.A.Sharov V.M.Timokhin (St.Petersburg Polytechnical University, Russia) visited NIFS (S.Sudo and N.Tamura) from October 27th to December 3rd, 2012 to study a spatial structure of the ablation cloud of the Tracer-Encapsulated Solid Pellet by measuring a Stark broadening with a spatial resolution on LHD.
4) I.Tolistikhina (P.N. Lebedev Physical Institute) visited NIFS on 3 Dec. 2012 on the approach from the atomic process on the research for the Tungsten impurity behavior in plasmas.

- **Collaborations with Ukraine**

1) T.Ido (NIFS) attended the international conference on plasma physics and controlled fusion and international workshop on a role of radial electric field on plasma confinement in stellarator and tokamak, held in Alushta, Ukraine from 14 to 22, September. 2012 and present the invited talk on “Characteristics of energetic-particle driven GAM in the Large Helical Device”.
2) T.Ido (NIFS) attended International Conference and School on Plasma Physics and Controlled Fusion & Alushta International Workshop on the Role of Electric Fields in Plasma Confinement in Stellarators and Tokamaks held in Alushta, Ukraine from17 to 22 September 2012 to give an invited talk entitled “Characteristics of energetic‐particle driven geodesic acoustic mode in the Large Helical Device.”
3) B.Aleksey (National Science Center, Kharkov Institute of Physics and Technology) attended the 22nd International Toki Conference, held in Toki, Japan from 17 Nov. to 23 Nov. 2012 and discussed on "Electrostatic edge plasma turbulence in the Uragan-3M torsatron"

- **Collaborations with USA**

1) H.Kohno (Lehigh University) visited NIFS on 9 Feb. 2012 for making a seminar and inspecting LHD and VR systems.
2) (Coumbia U.)S.A.Sabbagh, (General Atomics)R.J.La Haye, N.Eidietis, E.J.Strait, R.K.Fisher, (Institute for Fusion Studies, U. Texas)R.Fitzpatrick, (MIT Plasma Science and Fusion Center)R.Granetz, (Oak Ridge National Laboratory)D.A.Spong, J.H.Harris, (Princeton University Plasma Physics Laboratory)M.Okabayashi, S.A.Lazerson, S.C.Jardin, E.Fredrickson (Princeton University)N.C.Logan, (University of Wisconsin-Madison)K.McCollam, J.Sarff visited NIFS in Mar. 2012 to attend the ITPA MHD and Energetic Particles Topical Group Meeting.
3) M.A.Shapiro (MIT) visited NIFS on 6 Mar. 2012 for collaborative research on the improvement of transmission efficiency in the high-power mm-wave transmission line for ECH.
4) L.M.Konstantin (Univ. Wisconsin-Madison, USA) visited Kyoto University and NIFS from 18 Mar. to 31 Mar. to discuss possible future collaboration between

LHD and HSX devices based on CWGM activity, and also to apply the GNET code (developed by S.Murakami, Kyoto Univ.) to HSX experimental analyses.

5) S.Ohdachi (NIFS) visited the Janella Farm at the Colorado University Boulder to inspect the bio-imaging research, from 25 Mar. to 1 Apr. 2012.
6) W.C.Horton (Institute of Fusion Studies, University of Texas at Austin) visited NIFS from 16 to 27 Apr. 2012, for collaborative research on the extended-MHD approach for Rayleigh-Taylor instability and the impurity transport simulation
7) H.Yamada (NIFS) visited PPPL for the Advisory Committee Meeting from 24 to 28, Apr., 2012.
8) R.Yasuhara, I.Yamada, T.Tokuzawa, K.Okada, Y.Nagayama, T.Ozaki, M.Nishiuraand C.Dong (NIFS) attended the 19th Topical conference high temperature plasma diagnostics (HTPD2012) held at Hyatt regency Monterey from May 5 to 12, 2012.
9) B.M.Idaho (ORNL) visited NIFS on 15 May. 2012 for discussion on the US-Japan TITAN project.
10) M.Vanderlaan (National High Magnetic Field Laboratory) visited NIFS on 21 May. 2012 to inspect experimental apparatus (including LHD) at NIFS.
11) S.Sudo (NIFS) attended the meeting of the Japan-US joint committee on Cooperation in Science and Technology, held in Washington (DoE), and he presented the prosperous collaborative activity on fusion science and technology between Japan and US, from 14 to 18 Jul. 2012.
12) K.Ogawa (NIFS) visited PPPL (Dr.D.S.Darrow) from 22 July 2012 to 30 July 2012 to study the self-shadow problem of the scintillator-based lost-fast ion probe.
13) A.Sagara, T.Muroga, H.hirooka and T.Goto (NIFS) attended the 20th Topical Meeting on the Technology of Fusion Energy (TOFE2012), held in Nashville, from 26 Aug. to 2 Sep. 2012.
14) A.Sagara (NIFS) attended the 11th US-Japan HPD workshop, 24th IAEA Fusion Energy Conference, and the 1st IAEA DEMO Program workshop, from 4 to 19 Oct. 2012.
15) T.Mito, S.Imagawa and Y.Hishinuma (NIFS) attended the Applied Superconducting Conference 2012, held in Oregon, from 7 to 14 Oct. 2012.
16) S.Morita (NIFS) stayed in Washington DC from 29th September to 6th October 2012 to attend 8th ICAMDATA conference at NIST and in San Diego from 7th to 14th October 2012 to attend 24th IAEA FEC conference.
17) C.Dong (NIFS) visited US from 29 Sep. to 15 Oct. 2012, and made an invited talk in the ICAMDATA conference (at National Institute of Standards and Technology), and the 24th IAEA Fusion Energy Conference.
18) N.Yanagi (NIFS) attended the US-Japan workshop on superconductivity and 24th IAEA Fusion Energy Conference, from 4 to 14 Oct. 2012.
19) P.Zhu (Univ. Wisconsin-Madison) visited NIFS from July 1 to Oct. 7 to develop modeling of ELM physics on benchmark between MIPS and NIMROD codes, 2fluid MHD model of kinetic ballooning, and 3D shaping effects on edge stability.
20) N.Pablant (PPPL) stayed in NIFS from 24th September to 6th October 2012 to install a new X-ray detector on XICS of LHD.
21) O.Kaneko, S.Okamura, M.Kobayashi, S.Sakakibara, K.Ida, K.Tanaka, S.Mutoh, H.Takahashi, A.Iwamoto, T.Tanaka, T.Watanabe, A.Ishizawa, M.Sato, N.Nakajima, S.Toda, N.Mizuguchi, K.Ichiguchi and Y.Yoshimura (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), in Oct. 2012.
22) Y.Todo (NIFS) attended the 24th IAEA Fusion Energy Conference and ITPA Energetic Particles Topical Group Meeting (San Diego), from 7 to 19 Oct. 2012.
23) Y.Suzuki (NIFS) attended the 24th IAEA Fusion Energy Conference and ITPA Plasma Edge-Pedestal Topical Group meeting (San Diego), from 7 to 19 Oct. 2012.
24) A.Nishimura (NIFS) attended the 24th IAEA Fusion Energy Conference and ITPA Energetic Particle Topical Group Meeting (San Diego), from 7 to 19 Oct. 2012.
25) H.Yamada (NIFS) attended 24th IAEA Fusion Energy Conference and 41st Executive Committee Meeting of IEA Implementing Agreement on Stellarator-Heliotron Concept (held in San Diego) from 7 to 15, Oct., 2012.
26) A.Komori (NIFS) attended 24th IAEA Fusion Energy Conference and 41st Executive Committee Meeting of IEA implementing Agreement on Stellarator-Heliotron Concept (held in San Diego) from 7 to 14, Oct., 2012.
27) M.Yokoyama (NIFS) attended (as a clerk) the 41st Executive Committee meeting of the IEA Implementing Agreement for Cooperation in Development of the Stellarator-Heliotron Concept on 9 Oct. 2012, held in San Diego. He also attended the 24th IAEA Fusion Energy Conference in San Diego in 8-13, Oct.2012, and presented the poster presentation with A.Dinklage (IPP) on transport model validation activity.
28) J.Miyazawa (NIFS) attended the 24th IAEA Fusion Energy Conference, and the 1st IAEA DEMO Program workshop, from 10 to 20 Oct. 2012.
29) T.Muroga (NIFS) attended the 24th IAEA Fusion Energy Conference, and the 1st IAEA DEMO Program workshop, from 11 to 20 Oct. 2012.
30) S.Satake (NIFS) visited University Wisconsin-Madison

(USA) from 15 to 26 Oct. to promote inter-machine collaboration on the simulation and experimental studies on plasma flow, viscosity, and confinement, as an activity of CWGM. He discussed with J. Talmadge applying FORTEC-3D code to analyze neoclassical transport and viscosity in HSX and to compare with PENTA code.

31) N.Pablant (PPPL) stayed in NIFS from 17th October to 15th December 2012 to join the LHD experiment and to analyze the data from XICS.
32) H.Sugama (NIFS) visited the Rhode Island Convention Center, Providence, US from October 28th to November 4th, 2012 to participate in the 54th Annual meeting of the APS Division of Plasma Physics. He made a presentation entitled “Extended gyrokinetic field theory for time-dependent magnetic confinement fields”.
33) H.Tsuchiya, R.Seki and K.Nagaoka (NIFS) attended the 54th APS-DPP annual meeting (Rhode Island Convention Center (Providence, RI) from 28 Oct. to 4 Nov. 2012.
34) Y.Narushima (NIFS) was invited to 17th workshop on MHD stability control at Columbia University, November 5-7, 2012. He presented "Flow effects on RMP field penetration in the LHD" as an invited talk.
35) H.Yamada (NIFS) visited PPPL for the Advisory Committee Meeting and for discussions on international collaboration between NIFS and PPPL, from 6 to 10, Nov., 2012.
36) D.Nishijima (University of California, San Diego) visited NIFS from 19 to 30, Nov. 2012 for joint experiment in LHD (plasma irradiation to Tungsten material).
37) A.Kuley (University of California, Irvine) and Y.Ren (PPPL) attended the 22nd International Toki Conference in Nov. 2012.
38) W.Wang (PPPL) attended the US-Japan JIFT workshop from 24 to 27, Nov. 2012.
39) O.Sinitsyn (University of Maryland) visited NIFS from 9 to 10 Dec. 2012.
40) F.Volpe (Columbia University) visited Kyoto Univ. from June 1 to Sep. 4, 2012 as a guest professor of Institute of Advanced Energy. He joined the Heliotron J experiment, especially electron cyclotron current drive experiment for Alfven Eigenmode stabilization. He also developed a radiometer system for electron Bernstein waves diagnostic, which is beneficial for electron temperature profile measurement in high-density plasmas.
41) G.Weir (PhD student, Univ. Wisconsin) visited Kyoto Univ. from July 7 to July 21, 2012. He joined the Heliotron J experiment, and learned a calibration method for multi-channel radiometer for electron temperature measurement. He obtained electron temperature profiles in ECH plasmas by using the calibration data.
42) Discussions with the HSX (Univ. Wisconsin) team and CTH (Auburn Univ.) team, groups of ORNL and PPPL, etc.) were kept along the same line as in 2012.

5.2 Plans for 2013

1) 11th CWGM will be held in CIEMAT in early 2013. Some LHD researchers are expected to participate.
2) M.Kisaki will visit Consorzio RFX (Italy) from Jan. 8 to Feb. 8 2013 to discuss results of benchmark test of simulation codes and modify the codes.
3) E.Winkler (IPP Greifswald) will visit NIFS from Feb. 1, 2013 to Jul. 31, 2014 to develop helium beam diagnostics for his Ph.D. study. We also intend to establish collaboration program between LHD and W7-X about edge and divertor physics.
4) T.Morisaki (NIFS) will visit Forschungszentrum Juelich GmbH (Juelich Germany) from Mar. 18 to 21 to participate in the 6th International Workshop on Stochasticity in Fusion Plasmas.
5) G.Kawamura (NIFS) will visit Cracow (Poland) from 22 to 26 September to attend the 14th International Workshop on Plasma Edge Theory in Fusion Devices.
6) T.Oishi (NIFS) will visit MIT Plasma Science and Fusion Center (Massachusetts, U.S.) on May 2013 for collaboration on impurity transport study based on experimental data of X-ray imaging crystal spectroscopy in Alcator C-Mod tokamak and LHD.
7) G.Kawamura (NIFS) will visit Forschungszentrum Juelich (Juelich Germany) for collaboration on modeling of plasma-wall interactions for impurity transport simulation.
8) G.Kawamura (NIFS) will visit Max-Plank-Institut fur Plasmaphysik (Greifswald Germany) for collaboration on simulation modeling of LHD SOL and divertor plasmas.

5.3 International Collaborations by the Heliotron J team at Kyoto University

- **Collaborations with Australia**

1) Discussions with H-1 team (ANU) were kept along the same line as in 2012.

- **Collaborations with EU**

1) D.Pretty (Australian National University) visited Kyoto University from Feb. 8 to Feb. 19, 2012. Concerning the application of data mining technique to MHD

datasets of Heliotron J plasmas, he tried to apply a new clustering method "stream clustering algorithm (SWM11)" which has been successfully applied to the datasets of H1-NF. He also discussed the MHD database to get a unified knowledge of MHD stability in stellarator/heliotron devices based on CWGM activity.

2) S.Yamamoto visited CIEMAT from March 11 to March 18, 2012. He joined the TJ-II experiment to investigate the characteristics of energetic-ion-driven MHD instabilities such as Alfvén eigenmodes (AEs) in low magnetic shear stellarator/heliotron plasmas. He focused on the iota dependence of AE and the effect of AE on energetic ion transport. He obtained the iota dependence of AE using by the iota scan experiment where the iota was varied dynamically and shot by shot in TJ-II.
3) A.Alonso (CIEMAT) visited Kyoto University from March 4 to 10, 2012. He joined a bias experiment in Heliotron J, which is a collaboration research program among Tohoku University, NIFS and Kyoto University, to investigate the influence of poloidal viscosity on transition phenomenon. He has an experience of the similar experiment in TJ-II Stellarator and made contribution to the experiment in Kyoto.
4) K.Mukai (Kyoto University) visited CIEMAT from March 11 to March 18, 2012. He joined TJ-II experiments and had a collaboration work related to a reflectometer system for measurement of electron density profile and electron density fluctuation with T. Estrada. He estimated the radial electric field from Doppler shift of the frequency spectra.
5) S.Ohshima visited Stuttgart University from on March 17 to 31, 2012. He had a discussion with Dr.M.Ramisch for the activity of turbulence database on the framework of coordinated working group meeting (CWGM) for Stellarator/Heliotron Studies. They exchanged the information of turbulence study in Heliotron J and TJ-K device and shared the information of current status and problems of the turbulence database. They also agreed to continue to collaborate and keep in close touch with each other for this activity.
6) S.Yamamoto visited IPP, Greifswald from May 5 to May 9, 2012. He joined 10th coordinated working group meeting (CWGM) and made a presentation about possibilities for joint experiment at Heliotron J including present status and plan, and present status of energetic particle session in CWGM. In the introduction of joint experiment at Heliotron J, he mainly introduced on-going international research collaborations including the topics of ECCD collaborating with IPP and Edge fluctuation collaborating with Stuttgart University.
7) S.Yamamoto visited CIEMAT from May 10 to May 24, 2012. He mainly analysed and discussed the iota dependence of AEs in low magnetic shear stellarator/heliotron plasma in TJ-II. In order to identify and clarify the characteristics of observed AEs, he compared the experimental results such as mode frequency and position with shear Alfven spectra where he considered the effect of three-dimensional magnetic field in TJ-II. From the results from TJ-II and Heliotron J, he concluded that global AEs (GAEs) are mainly observed in low magnetic shear helical plasmas and helicity-induced AEs (HAEs) are also destabilized in the case of high iota configuration.
8) K.Nagasaki had a collaboration research on ECH/ECCD physics with N.Marushchenko (IPP, Greifswald). They developed a ray tracing calculation code "TRAVIS" for the Heliotron J device to calculate the EC power deposition and EC driven current efficiency. The TRAVIS data was used for stabilization experiments of energetic-ion-driven MHD instabilities by ECCD. The results were presented in 24th IAEA Fusion Energy Conference held in San Diego, USA.
9) Discussions with W7 team (IPP) were kept along the same line as in 2012.
10) Collaborations with CIEMAT were continued along the same lines as in 2012.

- **Collaborations with Russia**

1) Discussions with Kurchatov Institute related to development of advanced stellarator/heliotron systems were kept along the same line as in 2011.

- **Collaborations with Ukraine**

1) Discussions with Kharkov team about the collaboration in U-2M project were kept along the same line as in 2011.

- **Collaborations with USA**

1) F.Volpe (Columbia University) visited Kyoto Univ. from June 1 to Sep. 4, 2012 as a guest professor of Institute of Advanced Energy. He joined the Heliotron J experiment, especially electron cyclotron current drive experiment for Alfven Eigenmode stabilization. He also developed a radiometer system for electron Bernstein waves diagnostic, which is beneficial for electron temperature profile measurement in high-density plasmas. He also took a lecture on wave physics to graduate students in a summer school.
2) G.Weir (Ph. D. student, Univ. Wisconsin) visited Kyoto Univ. from July 7 to July 21, 2012. He joined the Heliotron J experiment, and learned a calibration method for multi-channel radiometer for electron

temperature measurement. He obtained electron temperature profiles in ECH plasmas by using the calibration data.

3) Discussions with the HSX (Univ. Wisconsin) team and CTH (Auburn Univ.) team, groups of ORNL and PPPL, etc.) were kept along the same line as in 2012.

- **Others**

1) F.Sano, T.Mizuuchi, K.Nagasaki and H.Okada attended 18th International Stellarator/Heliotron Workshop & 10th Asia-Pacific Plasma Theory Conference, which was held in Australian National University, Canberra and Murramarang Resort, NSW, on Jan. 29 – Feb. 3.
2) New gas fuelling by supersonic molecular beam injection (SMBI) was successfully applied to ECH/NBI plasma in Heliotron J. The collaboration of fuelling control studies are being discussed with TJ-II team and NIFS.
3) Advanced ECH scenarios including ECCD and EBW heating/current drive were examined through Heliotron J/LHD experiments. Temperature measurement in over-dense plasmas using 35GHz EBW diagnostics was also discussed.

5.4 Plans for 2013

1) Plasma fluctuations and structural formation at core and edge regions will be measured with using diagnostics including a beam emission spectrometer, a reflectometer, SX array, Langmuir probes and fast CCD cameras under collaboration with CIEMAT. IPP and Stuttgart University and domestic universities.
2) Confinement improvement of particle, momentum and energy, especially the role of toroidal and poloidal rotation, will be investigated by controlling particle fuelling method and magnetic field configuration under collaboration with Kharkov Institute and CIEMAT.
3) Confinement control of high-energy particles by using the optimized field configuration based on the quasi-isodynamic concept will be examined through Heliotron J NBI/ICRF experiments.
4) MHD instabilities such as interchange instabilities and Alfven Eigenmode instabilities in low-magnetic shear configurations will be studied from the viewpoint of magnetic island control and suppression of energetic-ion loss under collaboration with CIEMAT and IPP.
5) NBI startup using a 2.45GHz microwaves will be performed for high-beta experiments and physics study of plasma production under collaboration with IPP.
6) ECCD experiments using 2nd harmonic 70GHz X-mode will be performed for control of MHD instabilities through rotational transform modification under collaboration with IPP and NIFS.
7) Electron Bernstein heating/current drive and Electron Bernstein emission diagnostics are prepared for overdense plasma heating and electron temperature profile measurement under collaboration with IPP and Columbia University.
8) Particle and heat transport control of edge plasmas will be investigated with regard to divertor optimization.
9) Kyoto University plans to transfer Varian gyrotrons and related components to ORNL.
10) Kyoto University and NIFS made an application of Joint research projects related to ECRH and ECCD physics and technology between Germany and Japan to Japan Society for the Promotion of Science. If approved, personal exchange including researchers and students will be performed.
11) B.Blackwell (Australian National University) plans to visit Kyoto Univ. on December 2012 for collaboration on MHD mode analysis in H-1 and Heliotron J.
12) D.S.Darrow (PPPL) plans to visit Kyoto Univ. in 2013 for collaboration research on lost-ion probe diagnostic.

6. Russia

6.1 International Collaborations in 2012

1) K.Dyabilin (Kurchatov Institute Moscow) to IPP Greifswald, 29.01. – 26.02.2012
2) M.Isaev (Kurchatov Institute Moscow) to IPP Greifswald, 29.01. – 11.02.2012
3) M.Mikhailov (Kurchatov Institute Moscow) to IPP Greifswald, 27.02. – 26.04.2012
4) T.Richert, J.Baldzuhn (IPP Greifswald) and T.Franke (IPP Garching) visited Budker Institute Novosibirsk, 16.06. – 20.06.2012
5) T.Richert (IPP Greifswald) visited Budker Institute Novosibirsk 11.09. – 27.09.2012
6) M.Mikhailov (Kurchatov Institute Moscow) to IPP Greifswald, 22.10. – 14.12.2012
7) N.Marushchenko (IPP Greifswald) visited IOFFE Institute St. Petersburg, 30.10. – 02.11.2012
8) A.Melnikov and L.Eliseev and members of the HIBP Kurchatov Institute team were visiting CIEMAT to investigate the structure of plasma potential and plasma fluctuations in ECRH and NBI plasmas (in Lithium coated wall conditions) and measurements with two slit HIBP detector. The second HIBP system has been built for long-range (zonal flows) correlation studies and the commissioning is planned for beginning 2013.
9) Collaboration with General Physics Institute, Moscow on the characterization of the plasma reflected power on gyrotron performance. This includes preparation and installation of experimental systems in TJ-II, participation in experiments and analysis of the results. The visiting scientists of GPI involved have been:

D.Malakhov (19 March-19 April and 23 October-22 December), Y.Bondar (19 March-19 April), N.Kharchev (26 April-26 May and 27 September-26 October), V.Borzosekov (26 April-26 May), E.Konchekov (27 September-26 October), K.Sarksyan (2 -16 October)

10) P.Aleynikov, S.Konovalov, V.Lukash and V.D.Pustovitov (Kurchatov Institute) visited NIFS in Mar. 2012 to attend the ITPA MHD and Energetic Particles Topical Group Meeting.
11) M.Goto (NIFS) attended the International Conference on Spectral-line Profiles, held in St. Petersburg in June 2012.
12) I.A.Sharov V.M.Timokhin (St. Petersburg Polytechnical University, Russia) visited NIFS (S.Sudo and N.Tamura) from October 27th to December 3rd, 2012 to study a spatial structure of the ablation cloud of the Tracer-Encapsulated Solid Pellet by measuring a Stark broadening with a spatial resolution on LHD.
13) I.Tolistikhina (P.N. Lebedev Physical Institute) visited NIFS on 3 Dec. 2012 on the approach from the atomic process on the research for the Tungsten impurity behavior in plasmas.
14) Discussions between Kurchatov Institute and Kyoto University related to development of advanced stellarator/heliotron systems were kept along the same line as in 2011.

6.2 Plans for 2013

1) Continuation of the collaboration between General Physics Institute, Moscow (K.Sarksyan, N.Kharchev and GPI Team) and CIEMAT on the characterization of the plasma reflected power on gyrotron performance.
2) S.Pavlov (Kharkov Institute of Ukraine) will visit CIEMAT to work on ECRH theory.
3) S.Petrov and V.Nesenevich (IOFFE) will visit CIEMAT to participate on charge exchange spectrometry measurements.
4) A.Melnikov and L.Eliseev and members of the HIBP Kurchatov Institute team will visit CIEMAT to investigate the structure of plasma potential in ECRH and NBI plasmas (in Lithium coated wall conditions) and measurements using two HIBP systems for zonal flows experiments in the core plasma region.

7. Ukraine

7.1 Institute of Plasma Physics of the National Science Center " Kharkov Institute of Physics and Technology" of the NAS of Ukraine (IPP NSC KIPT, NASU)

7.1.1 International collaborations of the NSC KIPT in 2012

- **Collaboration with Technische universität Graz, Austria**

V.V.Nemov, S.V.Kasilov, and V.N.Kalyuzhnyj in cooperation with W.Kernbichler, M.Heyn (Association EURATOM-ÖAW, Institut für Theoretische Physik - Computational Physics, TU Graz, Petersgasse 16, A–8010 Graz, Austria) and J.Talmadge (University of Wisconsin-Madison, USA) fulfill calculations of collisionless α -particle losses for quasi-helically symmetric (QHS) toroidal stellarators in real space coordinates. The results show that the collisionless α -particle losses for QHS are negligible for particles started at $r/a \approx 0.25$. For particles started at $r/a \approx 0.5$ roughly a quarter would be lost. This is in agreement with the corresponding results in [W.Lotz, P.Merkel, J.Nührenberg, E.Strumberger, Plasma Phys. Control. Fusion, 34, 1037 (1992)] for $r/a \approx 0.25$ and somewhat exceeds those results for $r/a \approx 0.5$. For HSX device the particle losses are essentially larger than for QHS. The reason is connected with the presence of additional small magnetic field ripples in HSX. The amplitude of these ripples can be decreased by increasing the number of twisted coils. For such a system with 96 coils instead of 48 coils, the particle losses are decreased to a level comparable to that in QHS.

- **Collaborations with Sweden**

V.E.Moiseenko will continue the collaboration with O. Agren from Uppsala University on theoretical studies on fission-fusion hybrids.

- **Collaborations with Max-Planck-Institut für Plasmaphysik, EURATOM Association, Garching, Germany**

V.S.Voitsenya et al. (IPP NSC KIPT) in collaboration with Dr. M.Balden (IPP-Garching, Germany) suggested new model for development of relief on the surface of polycrystalline metal due to long term sputtering.

The results are reported at the International Conference on Plasma Physics and Controlled Fusion that was held during 17-22 September 2012 in Alushta (Crimea, Ukraine):

1) V.S.Voitsenya, M.Balden, A.F.Bardamid, V.N.Bondarenko, J.W.Davis, V.G.Konovalov, I.V. Ryzhkov, O.O.Skoryk, S.I.Solodovchenko, Zhou Zhang-jian. Development of surface relief on polycrystalline metals due to sputtering.

- **Collaborations with Department of Physics, University of Basel, Switzerland**

V.S.Voitsenya et al. (IPP NSC KIPT) in collaboration with Dr.B.Eren and Dr.L.Marot (Department of Physics,

University of Basel) studied the role of temperature in blistering of Mo film mirrors under exposure to ions of deuterium plasma.
The results are reported at the International Conference on Plasma Physics and Controlled Fusion that was held during 17-22 September 2012 in Alushta (Crimea, Ukraine): S.I.Solodovchenko, B.Eren, V.G.Konovalov, L.Marot, I.V.Ryzhkov, A.N.Shapoval, A.F.Shtan', O.O.Skoryk, V.S.Voitsenya. Temperature effects on behavior of Mo film mirrors under impact of deuterium plasma ions.

- **Collaboration with CIEMAT, Madrid, Spain**

Dr.L.I.Krupnik et al (IPP NSC KIPT) in collaboration with Dr.C.Hidalgo and TJ-II team (CIEMAT).

1) The first Heavy Ion Beam Probe system was upgraded to perform measurements of the electric fields and transport flows on TJ-II:
   - development and tuning new control and data acquisition systems,
   - fully inspection of the vacuum system,
   - new Cs emitter installation and tuning focusing system of the injector.
2) Providing the experiments with upgraded first HIBP diagnostic of the TJ-II Stellarator. Iinvestigation of the structure of plasma potential and plasma fluctuations in ECRH and NBI plasmas (inwith Lithium coated walls) and measurements with two slit HIBP detector. To start the related to the physical understanding of fluctuation induced transport in core and edge of plasma confinement volume.
3) Installation of the full parts of hardware (Injector and Detection systems) for second Heavy Ion Beam Probe diagnostic system on TJ-II stellarators. Testing of the second Injector.

- **Collaboration with Kurchatov Institute, Moscow, Russia**

Dr.L.I.Krupnik and HIBP team (IPP NSC KIPT) in collaboration with Dr.A.V.Melnikov and T-10 team (Kurchatov Institute)).

1) Installation and tuning new modification of the multi-sleet energy analyzer.
2) Investigations of the behavior of plasma potential and fluctuations by upgraded HIBP system in regimes with high plasma density. Comparative study of the GAMs (and AEs) behavior in the T-10 tokamak and TJ-II stellarator during ECR heating with high intensity heavy ion probing beam.
3) Providing the experiments directed to investigations of the Geodesic Acoustic modes and their features in the OH and ECRH regimes.

- **Conference participation**

1) V.E.Moiseenko: Conference on Plasma Physics and Controlled Fusion, Zvenigorod (Moscow reg.), Russia, February 6—10, 2012.
2) V.E.Moiseenko: Meeting on and technical aspects of volume sources of neutrons for materials science, technology research and problem solving for nuclear energy (VNS-5) Zvenigorod (Moscow reg.), Russia, June 4—8, 2012.
3) V.E.Moiseenko: International Conference on Open Magnetic Systems for Plasma Confinement (OS2012) and the International Workshop on Plasma Material Interaction Facilities for Fusion (PMIF), Tsukuba, Japan, August 27-31, 2012.
4) V.E.Moiseenko: First RCM of IAEA CRP F1.3015: Conceptual Development of Steady-State Compact Fusion Neutron Sources, IAEA, Vienna, 14-16 November, 2012.
5) 31 representatives of the Institute of Plasma Physics of NSC KIPT took part in the International Conference and school on Plasma Physics and Controlled Fusion that was held during 17-22 September 2012 in Alushta (Crimea, Ukraine).
6) A.Beletskii participated in the 22nd Toki Conference (Toki, Japan, Nov. 19-22, 2012).
7) A.Kasilov and V.Filiipov took part in Joint Experiment at the tokamak COMPASS in the Institute of Plasma Physics, Prague, Czech Republic (10-14 Sept. 2012) and in the COMPASS Programmatic Conference (17-18 Sept. 2012).
8) L.I.Krupnik ISHW/APPTC Conference, Australia 31.1-4.2 2012.
9) L.I.Krupnik, A.D.Komarov: EFTSOMP2010 - 14th Workshop on Electric Fields, Turbulence and Self-Organization in Magnetized Plasmas, Satellite meeting of the 39th EPS Plasma Physics Conference, Stockholm, Sweden, July 9 –10, 2012.
10) L.I.Krupnik, A.I.Zhezhera, G.N.Dezhko: International Conference and School on Plasma Physics and Controlled Fusion, Alushta (Crimea, Ukraine), September 22-27, 2012.

7.1.2 Plans for 2013 of the IPP NSC KIPT

- **Collaborations with Sweden**

V.E.Moiseenko will continue the collaboration with O.Agen from Uppsala University

- **Collaboration with Spain (CIEMAT, Madrid)**

1) Upgrade of the control and data acquisition system of the first HIBP equipment on TJ-II.
2) Tuning and start experiment of the second HIBP

system. Possibilities of this system were significantly expanded. Injector system with new extraction and focusing systems significantly improved the primary beam parameters: the intensity, stabilisation and focusing. In registration system of the secondary beam there was used two electrostatic energy analyzers. As a result, this year on the TJ-II will be used for plasma investigation two separate HIBP diagnostic systems disposed on 90° along the torus.

3) Study of the plasma potential and electron density during ECR and NBI heating in different magnetic configurations and regimes of device operation. Study of the plasma potential evolution and its fluctuations (Alfven and non-Alfven modes) in two cross-sections of plasma column in combined NBI/ECRH plasmas by two HIBP systems on TJ-II stellarator.

- Collaboration with Russian Kurchatov Institute, Moscow

1) Upgrade of the Thallium ion source on the tokamak T-10;
2) Study of the plasma potential and density and their fluctuations by upgraded HIBP system in regimes with high plasma density. Comparative study of the GAMs (and AEs) behavior in the T-10 tokamak and TJ-II stellarator during ECR heating with high intensity heavy ion probing beam.

- Collaboration with Ioffe Institute of Physics and Technology, St Petersburg, Russia

1) Upgrade of the secondary beam-line of HIBP diagnostic on TUMAN-3M tokamak.
2) Investigation of the electric field evolution and density and their fluctuations with NBI heating in various operational modes in the TUMAN-3M tokamak.

7.2 V.N.Karazin Kharkiv National University, Kharkiv

7.2.1 Collaborations with Institute of Physics, Ernst-Moritz-Arndt University, Greifswald, Germany

1) Rough surface sputtering. This year, the investigation the erosion of rough surface under ion beam bombardment has been continued. The total erosion yield of the Si pitch grating exposed to 6 keV Ar ion beam has been measured using Rutherford back-scattering analysis and these experimental data have been compared to results of the simulation using SDTrimSP-2D code. The numerical simulations show reasonable agreement with experimental results.

The new area of investigation has been entered with development of the steady-state high-flux Falcon ion source. This ion source is a versatile, compact, affordable, and highly functional in the research field of the fusion materials. The reversed magnetic field configuration of the source allows precise focusing of the ion beam into small spot of ≈3 mm and also provides the limited capabilities for impurity mass-separation. As the result, the source generates steady-state ion beam, which irradiates surface with high heat (0.3 – 21 MW m−2) and particle fluxes (4 × 10^21 – 3 × 10^23 m−2s−1), which approaches the upper limit for the flux range expected in ITER.

The results of this research were published:

1) Bizyukov I., Mutzke A., Mayer M., Langhuth H., Krieger K., Schneider R. Macroscopic parameters of the interaction of an Ar+ ion beam with a Si pitch grating// Nuclear Instruments and Methods in Physics Research, vol. B 278, pp. 4–7 (2012)
2) Girka O., Bizyukov I., Sereda K., Bizyukov A., Gutkin M., and Sleptsov V. Compact steady-state and high-flux Falcon ion source for tests of plasma-facing materials// Review Scientific Instruments, vol. 83, 083501 (2012)

- Collaborations with National Institute for Fusion Science, Toki, Japan

2) Minority ^{3}He heating in D-^{3}He fusion plasma. The numerical simulation of possibility of fusion reactivity enhancement due to ^{3}He minority ICRF heating in D-^{3}He fusion plasma is investigated analytically and numerically. The non-Maxwellian shape of the ^{3}He distribution function plays the key role for reactivity enhancement.

The modified values for reactivity rates were calculated basing on the distribution function profiles for different RF heating scenarios. It is calculated that the formation of the energetic tail due to RF heating is followed by significant reactivity increasing. We improve the statistic by increasing the number of test particles in numerical model.

The results of the research were presented on the conferences:

1) Shyshkin O.A., Moskvitin A.O., Moskvitina Yu.K. Modification of 3He minority distribution function in D plasma due to ICRF minority selective heating in ITER like toroidal configuration: Numerical simulations // International Conference – School on Plasma Physics and Controlled Fusion, Ukraine, Alushta (Crimea), September 17-22. P1-28. (2012)
2) Shyshkin O., Moskvitina Y., Moskvitin A., Yanagi N., Sagara A. Numerical Simulations for Fusion Reactivity Enhancement in D-3He and D-T Plasmas due to 3He and T Minorities Heating // 24th IAEA Fusion Energy Conference, USA, San Diego, October 8-13. – 2012. – TH/P6-28. (2012)

The results of this research were reported on the Conferences:

1) Mikhailenko V.S., Mikhailenko V.V. Magnetized plasma in strong electric field: from parametric turbulence to enhanced confinement// International Conference and School on Plasma Physics and Controlled Fusion Alushta (Crimea), Ukraine, September 17-22, 2012
2) Mikhailenko V.V., Lee H.J., Mikhailenko V.S., Koepke M.E. Drift and ion sound instabilities of the magnetic field aligned shear flow with inhomogeneous ion temperature// 54th Annual Meeting of the American Physical Society Division of Plasma Physics, Providence, Rhode Island, USA, October 29 - November 2, 2012
3) Mikhailenko V.V., Lee H.J., Mikhailenko V.S., Non-modal analysis of the diocotron instability// 22-nd International Toki Conference, Toki, Japan, November 19-22, 2012

The results of this research were published:

1) Mikhailenko V.V., Lee H.J., Mikhailenko V.S. Non-modal analysis of the diocotron instability: Plane geometry// Physics of Plasmas, vol. 19, 082112 (8 pages) (2012)
2) Mikhailenko V.V., Mikhailenko V.S., Lee H.J. Non-modal kinetic theory of the hydrodynamic drift instabilities of plasma shear flows// submitted to Nuclear Fusion (2012)

8. United States

8.1 International Collaborations in 2012

- **Collaborations with Australia**

1) ORNL (R.Goulding, J.Harris and P.Krstic) and ANU: development of the Materials Diagnostic Facility Prototype and ANU, and proposals for collaborative grants.
2) PPPL, DIIID and ANU – The effect of 3D magnetic perturbations on the edge plasma.
3) B.Breizman (Univ. of Texas, Austin), G.Chen (ORNL) and ANU: in helicon waves with the electromagnetic wave code EMS, as well as the formation of gaps and gap modes in a periodic linear machine.

- **Collaborations with Germany (IPP, Greifswald)**

1) P.Helander (IPP Greifswald) visited MIT Boston, 09.01. – 13.01.2012
2) O.Grulke (IPP Greifswald) visited PSFC/MIT, Boston, 04.02. – 13.02.2012
3) X.Sarasola Martin (IPP Greifswald) visited Columbia University, New York, 18.02.-18.03.2012
4) O.Grulke, T.Klinger (IPP Greifswald) to Kick-off-Meeting MPRC Princeton, 27.03. – 30.03.2012
5) P.Helander (IPP Greifswald) visited Princeton Plasma Physics Laboratory, 27.03. – 31.03.2012
6) G.Wurden (Los Alamos Energy Sciences, Los Alamos) to IPP, 20.05.-02.06.2012
7) J.Harris, D.Gates (Princeton Plasma Physics Laboratory, Princeton) to IPP Greifswald, 08.07. – 20.07.2012
8) A.Bader (University of Wisconsin) to IPP Greifswald, 29.07. – 10.08.2012
9) D.Mikkelsen (Princeton Plasma Physics Laboratory) to IPP Greifswald, 12.09. – 22.09.2012
10) H.Smith (IPP Greifswald) visited Princeton Plasma Physics Laboratory, 14.10. – 27.10.2012
11) T.Sunn Pedersen (IPP Greifswald) visited Columbia University, New York, 02.11. - 06.11.2012
12) X.Sarasola Martin (IPP Greifswald) visited Columbia University, New York, 01.12. - 15.12.2012

- **Collaborations with Spain (CIEMAT, Madrid)**

1) E.Hollmann (USCD) visited CIEMAT (1 week, June 2012) working on parallel / radial impurity transport studies.
2) K.McCarthy (CIEMAT) visited Oak Ridge National Laboratory (1 week, March 2012) for testing the TJ-II pellet injector, which was shipped to Ciemat in August 2012.
3) I.Calvo spent the month of September, 2012 at MIT to work on gyrokinetic theory.
4) E.R.Solano spent January 2012 in San Diego (DIII-D) to work on MHD dynamics and transport barriers.
5) F.Tabarés visited PPPL to discuss plasma-wall issues on Li coating.

- **Collaborations with Japan (NIFS and Kyoto University)**

1) H.Kohno (Lehigh University) visited NIFS on 9 Feb. 2012 for making a seminar and inspecting LHD and VR systems.
2) (Coumbia U.)S.A.Sabbagh, (General Atomics)R.J.La Haye, N.Eidietis, E.J.Strait, R.K.Fisher, (Institute for Fusion Studies, U. Texas)R.Fitzpatrick, (MIT Plasma Science and Fusion Center)R.Granetz, (Oak Ridge National Laboratory)D.A.Spong, J.H.Harris, (Princeton University Plasma Physics Laboratory)M.Okabayashi, S.A.Lazerson, S.C.Jardin, E.Fredrickson (Princeton University)N.C.Logan, (University of Wisconsin-Madison)K.McCollam, J.Sarff visited NIFS in Mar. 2012 to attend the ITPA MHD and Energetic Particles Topical Group Meeting.
3) M.A.Shapiro (MIT) visited NIFS on 6 Mar. 2012 for collaborative research on the improvement of transmission efficiency in the high-power mm-wave transmission line for ECH.
4) L.M.Konstantin (Univ. Wisconsin-Madison, USA) visited Kyoto University and NIFS from 18 Mar. to 31

Mar. to discuss possible future collaboration between LHD and HSX devices based on CWGM activity, and also to apply the GNET code (developed by S.Murakami, Kyoto Univ.) to HSX experimental analyses.

5) S.Ohdachi (NIFS) visited the Janella Farm at the Colorado University Boulder to inspect the bio-imaging research, from 25 Mar. to 1 Apr. 2012.
6) W.C.Horton (Institute of Fusion Studies, University of Texas at Austin) visited NIFS from 16 to 27 Apr. 2012, for collaborative research on the extended-MHD approach for Rayleigh-Taylor instability and the impurity transport simulation
7) H.Yamada (NIFS) visited PPPL for the Advisory Committee Meeting from 24 to 28, Apr., 2012.
8) R.Yasuhara, I.Yamada, T.Tokuzawa, K.Okada, Y.Nagayama, T.Ozaki, M.Nishiuraand C.Dong (NIFS) attended the 19th Topical conference high temperature plasma diagnostics (HTPD2012) held at Hyatt regency Monterey from May 5 to 12, 2012.
9) B.M.Idaho (ORNL) visited NIFS on 15 May. 2012 for discussion on the US-Japan TITAN project.
10) M.Vanderlaan (National High Magnetic Field Laboratory) visited NIFS on 21 May. 2012 to inspect experimental apparatus (including LHD) at NIFS.
11) S.Sudo (NIFS) attended the meeting of the Japan-US joint committee on Cooperation in Science and Technology, held in Washington (DoE), and he presented the prosperous collaborative activity on fusion science and technology between Japan and US, from 14 to 18 Jul. 2012.
12) K.Ogawa (NIFS) visited PPPL (Dr.D.S.Darrow) from 22 July 2012 to 30 July 2012 to study the self-shadow problem of the scintillator-based lost-fast ion probe.
13) A.Sagara, T.Muroga, H.hirooka and T.Goto (NIFS) attended the 20th Topical Meeting on the Technology of Fusion Energy (TOFE2012), held in Nashville, from 26 Aug. to 2 Sep. 2012.
14) A.Sagara (NIFS) attended the 11th US-Japan HPD workshop, 24th IAEA Fusion Energy Conference, and the 1st IAEA DEMO Program workshop, from 4 to 19 Oct. 2012.
15) T.Mito, S.Imagawa and Y.Hishinuma (NIFS) attended the Applied Superconducting Conference 2012, held in Oregon, from 7 to 14 Oct. 2012.
16) S.Morita (NIFS) stayed in Washington DC from 29th September to 6th October 2012 to attend 8th ICAMDATA conference at NIST and in San Diego from 7th to 14th October 2012 to attend 24th IAEA FEC conference.
17) C.Dong (NIFS) visited US from 29 Sep. to 15 Oct. 2012, and made an invited talk in the ICAMDATA conference (at National Institute of Standards and Technology), and the 24th IAEA Fusion Energy Conference.
18) N.Yanagi (NIFS) attended the US-Japan workshop on superconductivity and 24th IAEA Fusion Energy Conference, from 4 to 14 Oct. 2012.
19) P.Zhu (Univ. Wisconsin-Madison) visited NIFS from July 1 to Oct. 7 to develop modeling of ELM physics on benchmark between MIPS and NIMROD codes, 2fluid MHD model of kinetic ballooning, and 3D shaping effects on edge stability.
20) N.Pablant (PPPL) stayed in NIFS from 24th September to 6th October 2012 to install a new X-ray detector on XICS of LHD.
21) O.Kaneko, S.Okamura, M.Kobayashi, S.Sakakibara, K.Ida, K.Tanaka, S.Mutoh, H.Takahashi, A.Iwamoto, T.Tanaka, T.Watanabe, A.Ishizawa, M.Sato, N.Nakajima, S.Toda, N.Mizuguchi, K.Ichiguchi and Y.Yoshimura (NIFS) attended the 24th IAEA Fusion Energy Conference (San Diego), in Oct. 2012.
22) Y.Todo (NIFS) attended the 24th IAEA Fusion Energy Conference and ITPA Energetic Particles Topical Group Meeting (San Diego), from 7 to 19 Oct. 2012.
23) Y.Suzuki (NIFS) attended the 24th IAEA Fusion Energy Conference and ITPA Plasma Edge-Pedestal Topical Group meeting (San Diego), from 7 to 19 Oct. 2012.
24) A.Nishimura (NIFS) attended the 24th IAEA Fusion Energy Conference and ITPA Energetic Particle Topical Group Meeting (San Diego), from 7 to 19 Oct. 2012.
25) H.Yamada (NIFS) attended 24th IAEA Fusion Energy Conference and 41st Executive Committee Meeting of IEA Implementing Agreement on Stellarator-Heliotron Concept (held in San Diego) from 7 to 15, Oct., 2012.
26) A.Komori (NIFS) attended 24th IAEA Fusion Energy Conference and 41st Executive Committee Meeting of IEA implementing Agreement on Stellarator-Heliotron Concept (held in San Diego) from 7 to 14, Oct., 2012.
27) M.Yokoyama (NIFS) attended (as a clerk) the 41st Executive Committee meeting of the IEA Implementing Agreement for Cooperation in Development of the Stellarator-Heliotron Concept on 9 Oct. 2012, held in San Diego. He also attended the 24th IAEA Fusion Energy Conference in San Diego in 8-13, Oct.2012, and presented the poster presentation with A.Dinklage (IPP) on transport model validation activity.
28) J.Miyazawa (NIFS) attended the 24th IAEA Fusion Energy Conference, and the 1st IAEA DEMO Program workshop, from 10 to 20 Oct. 2012.
29) T.Muroga (NIFS) attended the 24th IAEA Fusion Energy Conference, and the 1st IAEA DEMO Program workshop, from 11 to 20 Oct. 2012.

30) S.Satake (NIFS) visited University Wisconsin-Madison (USA) from 15 to 26 Oct. to promote inter-machine collaboration on the simulation and experimental studies on plasma flow, viscosity, and confinement, as an activity of CWGM. He discussed with J. Talmadge applying FORTEC-3D code to analyze neoclassical transport and viscosity in HSX and to compare with PENTA code.
31) N.Pablant (PPPL) stayed in NIFS from 17th October to 15th December 2012 to join the LHD experiment and to analyze the data from XICS.
32) H.Sugama (NIFS) visited the Rhode Island Convention Center, Providence, US from October 28th to November 4th, 2012 to participate in the 54th Annual meeting of the APS Division of Plasma Physics. He made a presentation entitled “Extended gyrokinetic field theory for time-dependent magnetic confinement fields”.
33) H.Tsuchiya, R.Seki and K.Nagaoka (NIFS) attended the 54th APS-DPP annual meeting (Rhode Island Convention Center (Providence, RI) from 28 Oct. to 4 Nov. 2012.
34) Y.Narushima (NIFS) was invited to 17th workshop on MHD stability control at Columbia University, November 5-7, 2012. He presented "Flow effects on RMP field penetration in the LHD" as an invited talk.
35) H.Yamada (NIFS) visited PPPL for the Advisory Committee Meeting and for discussions on international collaboration between NIFS and PPPL, from 6 to 10, Nov., 2012.
36) D.Nishijima (University of California, San Diego) visited NIFS from 19 to 30, Nov. 2012 for joint experiment in LHD (plasma irradiation to Tungsten material).
37) A.Kuley (University of California, Irvine) and Y.Ren (PPPL) attended the 22nd International Toki Conference in Nov. 2012.
38) W.Wang (PPPL) attended the US-Japan JIFT workshop from 24 to 27, Nov. 2012.
39) O.Sinitsyn (University of Maryland) visited NIFS from 9 to 10 Dec. 2012.
40) F.Volpe (Columbia University) visited Kyoto Univ. from June 1 to Sep. 4, 2012 as a guest professor of Institute of Advanced Energy. He joined the Heliotron J experiment, especially electron cyclotron current drive experiment for Alfven Eigenmode stabilization. He also developed a radiometer system for electron Bernstein waves diagnostic, which is beneficial for electron temperature profile measurement in high-density plasmas.
41) G.Weir (PhD student, Univ. Wisconsin) visited Kyoto Univ. from July 7 to July 21, 2012. He joined the Heliotron J experiment, and learned a calibration method for multi-channel radiometer for electron temperature measurement. He obtained electron temperature profiles in ECH plasmas by using the calibration data.
42) Discussions with the HSX (Univ. Wisconsin) team and CTH (Auburn Univ.) team, groups of ORNL and PPPL, etc.) were kept along the same line as in 2012.

Appendices: Technical Reports on 2012 Activities on LHD and Wendelstein 7-X

Highlights of LHD Experiments

In 2012, the Large Helical Device (LHD) comes to its 16th experimental campaign (Plasma experiment: from 17 Oct. to 6 Dec. 2012). Progress being made in this experimental campaign will be reported after it finishes and detailed analyses are made.

Baffle-structure to accommodate closed helical divertor has been installed in 8 toroidal sections (from 2 in 2011) of inboard side. A cryo-pumping apparatus for one section has become available so as to assess its pumping capability under the real experimental condition. The one of important missions in this campaign is, then, initial documentation of particle-control capability in the edge of plasmas by means of closed helical divertor. Characterization of high-temperature, high-beta and steady-state plasmas under the modified in-vessel components is a main issue to prospect the next step with larger pumping capability. A newly installed 154GHz-1MW gyrotron (developed under the bi-lateral collaborative framework with Tsukuba University) came in operation. It should increase the local-heating capability in wider range of magnetic configuration and high density regime in combination with already installed 77GHz gyrotron.

Detailed physics studies will be enhanced in expanded LHD parameter regimes such as, detached divertor, resonant magnetic perturbation, stochastization of magnetic fields, magnetic island dynamics, ion heat transport, momentum transport, non-local transport, energetic particles-driven instability, atomic and molecular dynamics, and plasma-wall interaction.

Integration of performance extension and physics understandings progressed in LHD experiment successfully sent 21 papers to the 24th IAEA Fusion Energy Conference (San Diego, Oct. 2012). The 4 (3) of them were presented by domestic (international) collaborators as their first authors.

This fact indicates that LHD has provided opportunities to international as well as domestic collaborations by providing plasmas in a wide range of parameters. The number of international participants to LHD experiment has steadily increased, and it has reached more than 70 in 2011. The LHD Experiment Technical Guide was updated (all in English), and can be found at http://www.lhd.nifs.ac.jp/lhd/databook_2012/. LHD Physics Meeting has been run in English for physics and technical presentations. We hope this management will be of your help to further facilitate to join the LHD experiment.

Progress Report on Wendelstein 7-X Construction

The Wendelstein 7-X project coordinates human resources, technical activities, the technical part of industry contracts and the contributions from other research centres and takes care of the interfaces between physics and engineering.

The collaboration with other institutions is of utmost importance for the Wendelstein 7-X project. KIT, FZJ and CEA provide immediate support via the supply of technical components and tests for Wendelstein 7-X subsystems. EURATOM continues to support the project with senior experts consulting on key project tasks. Experts from FZJ are strongly involved in the development of diagnostics.

Cooperation with KIT on the ECRH system is running well. The collaboration with KIT also includes the design and construction of the current leads for the superconducting coils.

The collaboration with Polish research institutes is running smoothly. The activity of the Institute for Nuclear Physics of the Polish Academy of Sciences in Krakow (IFJ PAN), which has provided up to 20 technicians and engineers for assembly of the bus-bar system, has come to an end. IPJ Swierk is continuing their work on the neutral beam injection system for W7-X. Various diagnostic systems are developed by Polish institutes and universities.

Within the collaboration with US laboratories, PPPL will provide the trim coils for W7-X and the respective power supplies. Four out of the five coils have already been delivered to Greifswald. ORNL is developing a design for the divertor scraper element, an additional High Heat Flux component to protect the W7-X plasma vessel during plasma start-up with high power discharges. LANL is developing a fast infrared camera system for divertor monitoring.

(Komori, A., Yamada, H., Yokoyama, M.)