Implementing Agreement for Co-operation in Development of the Stellarator-Heliotron Concept

2013 Executive Committee Annual Report to the Fusion Power Coordination Committee

January 2014

Committee Chair:

A. Komori (National Institute for Fusion Science, Japan)

Committee Members:

D.T. Anderson (University of Wisconsin-Madison, USA)

B. Blackwell (The Australian National University, Australia)

I. E. Garkusha (Institute of Plasma Physics of the National Scientific Center, Kharkov Institute of Physics and Technology, Ukraine)

J. H. Harris (The Australian National University, Australia)

L. M. Kovrizhnykh (Institute of General Physics, Russian Academy of Science, Russia)

D. Prokhorov (ROSATOM, Russia)

J. Sanchez (Laboratorio Nacional de Fusión, Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas, Spain)

V.S. Voitsenya (Institute of Plasma Physics, National Science Centre, Kharkov Institute of Science and Technology)

R. Wolf (Max-Planck-Institut für Plasmaphysik, Germany)

H. Yamada (National Institute for Fusion Science, Japan)

M. C. Zarnstorff (Princeton Plasma Physics Laboratory, USA)

Alternates:

C. Hidalgo (Laboratorio Nacional de Fusión, Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas, Spain)

T. Klinger (Max-Planck-Institut für Plasmaphysik, Germany)

Secretary:

M. Yokoyama (National Institute for Fusion Science, Japan)

EXECUTIVE SUMMARY

The present report overviews the scientific and technical progress achieved in 2013 by the parties to the Implementing Agreement for Co-operation in Development of the Stellarator-Heliotron Concept, who have greatly benefit from its international collaborative framework. The document reports the collaborations in 2013 and the parties' research plans for 2014, including technical reports on 2013 activities.

TABLE OF CONTENTS

1 19TH INTERNATIONAL STELLARATOR-HELIOTRON WORKSHOP (JOINT WITH 16TH IEA RFP WORKSHOP)

The 19th International Stellarator-Heliotron Workshop was held in Padova, Italy from 16 to 20 September, 2013, which is jointly organized with 16th IEA RFP Workshop.

The idea of this joint workshop was originated at the 41st Stellarator-Heliotron (SH) Executive Committee Meeting (at the Australian National University in 30 January, 2013). During that meeting, it was pointed out that RFP research had focused on recently-found appearance of three-dimensional structure at the core region, and it was suggested to promote mutual understandings and collaborations among Stellarator-Heliotrons (SH) and RFPs through joint workshop. Primary point of contacts is three-dimensional structure. This idea was also supported by RFP communities, to realize this joint workshop.

188 researchers from 13 countries participated and the total of 168 presentations were provided. This large number of participations and presentations is one of proofs of the success of this joint workshop.

The international program committee (IPC) for this joint workshop was formed as B.Blackwell (ANU, SH side) and M.E.Puiatti (RFX, RFP side) as co-chairs. The entire program (except detailed list of poster presentations) is attached below for reference.

Extensive efforts were made to form the workshop program to effectively facilitate mutual understandings between SH and RFPs. One of such efforts was to implement introductory talks for both concepts at the beginning of workshop. IPC appointed the following 2 speakers for such an intention.

- H.Yamada (NIFS): “Alternative and Complementary Role of Stellarator-Heliotron and RFP towards Comprehensive Understanding from Configuration Zoology -- Remarks from Stellarator-Heliotron Studies --”: Assessment of configuration optimization and performance extension through making full use of advantages of SH towards comprehensive and exact understanding of toroidal plasmas are emphasized. It is anticipated that SH as well as RFP make critical contributions to three-dimensional (3D) physics which is definitely required for tokamaks as well, and this joint workshop to be the touchstone.
- J.Sarff (UW-Madison): “Introduction to the RFP”: Multi-configuration (from standard RFP to either current profile control or single-helicity self-organization (where 3D-sturucture becomes apparent)) research towards improved confinement in RFP is emphasized, along with the critical issues such as current sustainment and boundary control. It is anticipated this joint workshop to provide options for solving remaining difficult challenges for magnetic fusion through SH and RFP pairing.

These 2 introductory talks were followed by the complementary invited talk by C.Hegna (UW-Madison) on theoretical aspects; “Differences and Similarities in the 3D Physics of Stellarator-Heliotrons and Reversed Field Pinches”. Several physics topics such as 3D equilibrium reconstruction, magnetic island dynamics, energetic ion confinement, impurities, micro-instabilities, divertor physics etc., are introduced complementarily from both SH and RFP. These consecutive 3 talks successfully establish bases for mutual understandings between SH and RFP, and then productive discussions throughout the joint workshop.

The workshop program was organized by topics-basis. The discussion time was allocated at the end of each topical session, so that the overall discussions, bridging SH and RFP beyond the individual presentation, could be enhanced. Among several physics topics, stochastic magnetic field (e.g., invited talk by K.Ida (NIFS)) and 3D equilibrium reconstruction (several practical applications of 3D equilibrium codes both to SH and RFP) were the most overlapping and extensively-discussed sessions.

Based on this successful joint workshop, it has been agreed between SH and RFP Executive Committees to maintain some topical-basis overlapping in the next individual workshop (both in 2015, SH in Germany and RFP in China) (cf., Minutes of 42nd Stellarator-Heliotron Executive Committee Meeting, Sec. 4.).

Joint 19th ISHW and 16th IEA-RFP workshop
16-20 September 2013, Padova, Italy

Monday, September 16

	7:45		**Registration at "Palazzo del Bo" University of Padova**			
	8.30		Welcome		20	
			Introductory - Chair: Piovan			
	8.50	**H. Yamada**	**Stellarator and Heliotron introduction**		40	
	9.30	**J. Sarff**	**RFP introduction**		40	
	10.10		**Coffee break**		30	
	10.40	**C. Hegna**	**Theory introduction:** Differences and Similarities in the 3-D Physics of Stellarator/Heliotrons and Reversed Field Pinches	IL1	40	
			Experiments - Chair: Puiatti			
	11.20	**M. Valisa**	RFX-mod: Recent Achievements and Future Perspectives in the Context of the European Roadmap	IL2	30	
	11.50	**T.S.Pedersen**	Progress on the construction and plans for commissioning and first plasmas on W7-X	IL3	30	
	12.20		**Lunch**		90	
	13.50	**F. Sano**	New results from high-density NBI operation of Heliotron J	IL4	30	
	14.20	**W. Liu**	Progress of the Keda Torus eXperiment Project in China Design and Mission	O1	20	
	14.40		**Discussion**		20	
			Impurities - Chair: Tabares			
	15.00	**S. Morita**	Two-dimensional study of edge impurity transport in LHD	IL5	30	
	15.30	**T. Morisaki**	Radiated Power Distributions during Impurity Injection Discharges in LHD	O2	20	
	15.50		**Coffee Break**		30	
	16.20	**J.M. Garcia-Regana**	Electrostatic potential variation within flux surfaces and its impact on impurity transport in stellarators	IL6	30	
	16.50	**L. Carraro**	Impurity screening in RFX-mod RFP plasmas	IL7	30	
	17.20	**V. Mirnov**	Classical Confinement of Impurities in RFP Plasmas	O3	20	
	17.40		**Discussion**		30	
	18.10		***End***			
	19.30		***Welcome reception at Caffé Pedrocchi***			

Tuesday, September 17

	8.20		Poster opening (Agorà)		10	
			3D equilibria – Chair: Hegna			
	8.30	**J.D. Hanson**	Three Dimensional Equilibrium Reconstruction in Stellarators, RFPs and Tokamaks	IL8	30	
	9.00	**B. Chapman**	Unified parametric dependence, control, and reconstruction of 3D equilibria in the RFP	O4	20	
	9.20	**D. Terranova**	Helical equilibrium reconstruction with diagnostics in the RFX-mod reversed field pinch	O5	20	
	9.40	**S. Lazerson**	3D Equilibrium Diagnostic Response for W7-X and ITER	O6	20	
	10.00		**Coffee break**		30	
	10.30	**G.R. Dennis**	A minimally constrained model of self-organized helical states in reversed-field pinches	IL9	30	
	11.00	**W.A. Cooper**	3D Physics Studies in Tokamak Devices	IL10	30	
	11.30		**Discussion**		20	
	12.00		**Lunch**		90	
	13.30		Poster session		170	
	15.20		**Coffee Break**		30	
			Transport I – Chair: Beidler			
	15.50	**R. Wilcox**	Measurements of the contribution of Reynolds stress to momentum balance in HSX	O7	20	
	16.10	**G. Weir**	Electron heat transport experiments and stiffness in the heat flux on the HSX stellarator	IS1	20	
	16.30	**M. Gobbin**	eITBs dynamics in helical RFX-mod states by high time resolution Te measurements	O8	20	
	16.50	**S. Murakami**	Confinement properties of high temperature plasma and integrated simulation of heat transport in LHD	O9	20	
	17.10	**N. Pablant**	Investigation of ion and electron heat transport of high-Te ECH heated discharges in the Large Helical Device	O10	20	
	17.30		**Discussion**		30	
	18.00		***End***			

Wednesday, September 18

			MHD and stochastic – Chair: Chapman			
	8.30	**K. Ida**	Topology bifurcation of a magnetic flux surface in LHD plasmas	IS2	20	
	8.50	**S. Masamune**	MHD mode dynamics associated with helical RFP state in RELAX	IS3	20	
	9.10	**H. Tsuchiya**	Core Temperature Flattening by Stochastization on ITB plasma in LHD	O11	20	
	9.30	**D. Bonfiglio**	Impact of helical magnetic boundary in 3D nonlinear MHD physics of the helical RFP	O12	20	
	9.50		**Coffee break**		30	
			MHD – Chair: Ida			
	10.20	**D.A. Spong**	Shear Alfvén instabilities in 3D toroidal configurations	IL11	30	
	10.50	**K. Ogawa**	Energetic-ion losses caused by MHD activities resonant and non-resonant with energetic ions in LHD	IS4	20	
	11.10	**S. Ohdachi**	MHD activities destabilized in the stochastic region of the Large Helical Device	O13	20	
	11.30	**S. Yamamoto**	External control of energetic-ion-driven MHD instabilities by ECH/ECCD in helical plasmas	IS5	20	
	11.50	**P. Terry**	Magnetic Turbulence Suppression by a Helical Mode	O14	20	
	12.10		**Lunch**		90	
	13.40	**B.D. Blackwell**	Fluctuations in the Alfvén Range of Frequencies in the H-1NF Heliac	IL12	30	
	14.10		Discussion		20	
			Turbulence – Chair: Martin			
	14.30	**H. Takahashi**	Study of transition phenomena based on poloidal ion viscosity using a biasing electrode in helical system	IL13	30	
	15.00	**P. Xantopoulos**	Properties and scaling of gyrokinetic ITG turbulence in stellarator configurations	IS6	20	
	15.20	**H. Mynick**	Designing stellarators & tokamaks for reduced turbulent transport	O15	20	
	15.40		**Coffee Break**		30	
	16.10	**I. Calvo**	Calculating the radial electric field in quasisymmetric stellarators	IL14	30	
	16.40		**Discussion**		20	
	17.00		***RFX laboratory and ITER BEAM yard tour. Transfer to research area***			

Thursday, September 19

8.20		Poster opening (Agorà)		10
		Turbulence – Chair: Helander		
8.30	**C. HIdalgo**	Isotope effect on zonal flows: experiments in the TEXTOR tokamak and TJ-II stellarator	IL15	30
9.00	**T. Estrada**	Spatial, temporal and spectral structure of the turbulence-flow interaction at the L-H and L-I-H transitions in TJ-II plasmas	O16	20
9.20		**Discussion**		20
9.40		**Coffee break**		30
		Edge and PWI – Chair: Terranova		
10.10	**E. Oyarzabal**	TJ-II experiments for testing lithium as a possible PFC for a Fusion Reactor	IL16	30
10.40	**G. Spizzo**	Electric field and flows at the edge of toroidal fusion plasmas	IL17	30
11.10	**O. Scmitz**	Modeling of edge particle transport and divertor recycling with three-dimensional magnetic control fields applied for ELM control at ITER	O17	20
11.30	**M.A. Pedrosa (C. Hidalgo)**	Experimental evidence of asymmetries in edge plasma potential in the TJ-II stellarator	O18	20
11.50		**Discussion**		20
12.10		**Lunch**		80
13.30		Poster session		120
15.20		**Coffee Break**		30
		Edge and PWI – Chair: Harris		
15.50	**M. Kobayashi**	Effects of magnetic field structure of edge stochastic layer on radiative divertor operation in LHD	IL18	30
16.20	**S. Oshima**	Edge Plasma Behavior Affected by Energetic Particle Driven Instabilities in Heliotron J	O19	20
16.40	**A. Ware**	Impact of self-consistent bootstrap current on the magnetic structure of W7-X	O20	20
17.00	**J. Lore**	Design of High-heat-flux Divertor Scraper Elements for the W7-X Stellarator	O21	20
17.20		**Discussion**		20
		System – Chair: Harris		
17.40	**V.E. Moiseenko**	Research on Stellarator-Mirror Fission-Fusion Hybrid	IL19	30
18.10		**Discussion**		20
18.20		***End***		
20.00		***Banquet***		

Friday, September 20

		Transport II – Chair: Yokoyama			
8.30	**J. Anderson**	Energetic particle confinement and effects in axisymmetric and 3D RFP plasmas	IL20	30	
9.00	**D. Craig**	Ion Heating and Energization in MST	O22	20	
9.20	**P. Helander**	On trapped-particle instabilities in optimised stellarators	O23	20	
9.40	**S. Kobayashi**	Role of toroidal mirror ripple on parallel flow in NBI plasmas of Heliotron J	O24		
10.00		**Discussion**		20	
10.20		**Coffee break**		30	
		MHD control – Chair: Masamune			
10.50	**A. Boozer**	Plasma Sensitivity to External Magnetic Fields	IL21	30	
11.20	**E.A.Unterberg**	Measurements of Edge and Internal Plasma Displacements Due to Non-Axisymmetric Magnetic Perturbations on DIII-D	O25	20	
11.40	**L. Frassinetti**	Braking torque due to external perturbations in EXTRAP T2R	IS7	20	
12.00	**L. Piron**	Tearing mode control in the RFX-mod device	O26	20	
12.20	**J. Drake**	Overview of Experimental System Identification Results and Application to Control in Extrap T2R	O27	20	
12.40		**Discussion**		20	
13.00		**Lunch**		90	
		Perspectives – Chair: Blackwell			
14.30	**M.C.Zarnstorff**	Path to a Stellarator Demo	IL22	30	
15.00		Discussion		70	
16.20		***End***			

2 COORDINATED WORKING GROUP MEETING (CWGM) FOR STELLARATOR-HELIOTRON STUDIES

During year 2013, two CWGMs (11th and 12th) were held to continuously facilitate the joint activities.

11th CWGM

The 11th Coordinated Working Group Meeting (CWGM11) was held from 11 to 13, Mar. 2013 at CIEMAT in Madrid, Spain. In addition to local participation, video-conference participation was made from (alphabetic order of country name) IPP-Greifswald (Germany), NIFS, Kyoto University (Japan), Kharkov (Ukraine), PPPL and University of Wisconsin-Madison (USA). The materials presented in the 11th CWGM are available at http://ishcdb.nifs.ac.jp/ and http://fusionwiki.ciemat.es/wiki/Coordinated_Working_Group (→ CWGM11) for those of you having further interests. Below, you will find the overall summary of the meeting.

The meeting was opened by the welcome address from C. Hidalgo (CIEMAT), in which he mentioned the successful evolution of the CWGM activity for the promotion of the programmatic international collaboration towards systematic understandings, and for the contribution to the world-wide fusion development.

The meeting was composed of 10 sessions as follows:

Flows and viscosity

This session was launched at the previous CWGM (Greifswald, 6–8 June 2012). The evolution and this-year's plans among several helical devices were introduced. Simulation code Verification and Validation (to be reported in the coming International Stellarator-Heliotron Workshop [ISHW]) are underway utilizing experimental data from LHD, TJ-II, W7-AS and HSX. Extensions to the standard neoclassical assumptions, such as the non-local approach, the non mono-energetic treatment and the inclusion of $\boldsymbol{E}\times\boldsymbol{B}$ flow compressibility, will be emphasized owing to the capabilities of the FORTEC-3D code.

Bias experiments in four helical devices in Japan (Tohoku University Heliac, CHS, Heliotron-J [H-J] and LHD) were reviewed. It has been found that the required induced torque seems to increase as the effective ripple increases based on comparison among these devices. The international collaboration is valuable to extend the database. In this regard, the bias experiment in TJ-II on top of this report was discussed. It was pointed out that the "iota window" for H mode transitions in helical plasmas (observed in W7-AS, H-J and TJ-II) should be kept in mind as an extension of such bias experiment.

Isotope effect and multi-scale physics were considered based on experimental findings in TJ-II and TEXTOR. It was proposed to investigate the role of the symmetry properties of the magnetic field in HSX, where the possibility of performing deuterium plasma experiments will be considered. The isotope effect in regard to H mode power threshold has been one of the main issues in the ITPA, so that a link to ITPA activities is to be kept in mind.

3D equilibrium

The validation of HINT2 equilibrium calculations, which has been homework from the 10th CWGM, has progressed in the LHD. It has been systematically found that the effective boundary can be identified with the location of the maximum of the E_r (radial electric field) shear (deduced from charge exchange spectroscopy). The peak position of field lines' connection length (HINT2) has been found to fit the peak position of the heat flux to divertor plates (measured by IR-camera in collaboration between IPP and NIFS). The plasma response to three-dimensional (3D) magnetic fields will be reported in the invited talk at the 2013 EPS conference (already approved).

Database issues

The extension of the ISHPDB (International Stellarator-Heliotron Profile Database) has been progressing, but some physics topics have had no contributions to the database. As for magnetic configuration data, a minimum set of VMEC-files has been registered. An interface should be available since VMEC-versions may differ from institution to institution.

The extension of the ISHCDB (Confinement Database) towards predictive scaling is mandatory from different size and shape devices and different operation/parameter regimes. An extended joint EPS2012 paper is now in preparation as a publication in Plasma Physics and Controlled Fusion.

An extension of the CERC (Core Electron-Root Confinement) collaboration was proposed to include ECH plasmas in HSX, where data from steady-state power balance and perturbative heat transport can be studied in conditions of different degrees of symmetry in the magnetic configuration.

Energetic particles

International collaborations have been successfully developed among TJ-II, LHD, H-J, and data from CHS. The number of joint papers based on joint experiments has been steadily increasing. It was pointed out the outreach beyond Stellarator-Heliotron community through joint experiments conducted in the ITPA Energetic Particle Physics topical group.

The integrated approach, experiment/theory/simulation, was suggested in order to increase the predictive capability on Alfvén eigenmodes and energetic particles properties.

Transport

Significant plasma potential variation on a flux surface was observed in TJ-II/ECRH plasmas for the first time, which would have an impact on impurity transport such as in HDH (high-density H mode) in W7-AS and impurity hole in LHD, through ***E***pol×***B*** (radial) drift and parallel impurity transport mechanisms.

The status of the joint IAEA paper on neoclassical transport validation in LHD, TJ-II and W7-AS was reported. The energy transport studies are to be extended (candidate shots already identified from LHD) through the application of FORTEC-3D.

The integrated transport suite development (IPP: predictive, NIFS: experimental analysis) has been progressing. A modular ASTRA-core suite is available in CIEMAT for predictive/interpretative analysis (e.g. the ongoing NC-validation activity).

The ion temperature profile obtained by XICS (X-Ray Imaging Crystal Spectrometer) on LHD (in collaboration between PPPL and NIFS) has been incorporated into TASK3D-a suite.

Island dynamics

Recent progress on island experiment in LHD (investigating systematically the plasma parameter and magnetic configuration dependence) and joint-experiment plan in TJ-II (forcing the appearance of a iota=n/m=4/2 island with controlled Ohmic induction, where n (m) indicates toroidal (poloidal) mode numbers, respectively) were introduced. Such joint actions will be summarized, and conference presentations are planned in the coming ISHW (2013) and IAEA Fusion Energy Conference (2014). Heat pulse propagation experiments (via ECH modulation) in TJ-II jointly with NIFS colleagues, was also reported: instantaneous ECE response, associated to ECH pump-out, is found when an n/m=3/2 magnetic resonance reaches certain radial locations. VMEC calculations have been provided at various stages of the calculated evolution of the rotational transform as a basis for 3D-equilibrium analysis to be calculated by HINT2 code.

Link to ITPA

Strengthening of the link between ITPA and CWGM has been continuously promoted. The status of Integrated Operation Scenario (IOS) topical group was reported, with the emphasis on the contributions from S-H so far, such as ECH-assisted plasma breakdown and integrated modelling activities.

Recently, organizational process of SSOCG (Steady State Operations Coordination Group) has been progressed by calling the participation of related IEA (International Energy Agency) Implement Agreements and national laboratories. Actively cooled superconducting devices, such as LHD and Wendelstein 7-X in S-H community, should play leading roles in joint programmes to be formulated.

H mode

A revision of H mode phenomenology considering helical devices (W7-AS, CHS, TJ-II, H-J and LHD) highlighted both the generic nature of the H mode and its dependence on the 3D magnetic configuration. Therefore, a joint study of the configuration dependence was proposed under the hypothesis, termed “configuration-biased H mode”, that the spin-up of flows to a high-rotation state or the diverse edge instabilities may be biased (or damped) by specific flow conditions in each 3D magnetic configuration. An overview of related data from TJ-II showed a prominent role of low order rationals in H mode phenomenology, including bursty activity that might be put in common with tokamak physics. A *wiki* page has been setup to launch this joint activity and details will be announced soon[1].

The study dedicated to He plasmas (main ion species in the first phase of ITER, where the threshold power is to be studied) was suggested.

Reactor, system code

HELIAS reactor concept was introduced by emphasizing issues not directly covered by physics optimization for W7-X, and technological issues. Pellet fuelling has been planned in W7-X to deal with the development of reactor scenarios. It has been found that positive *E*r can arise for a hollow density profile, which might contribute to avoid impurity accumulation in the core plasma. Improved and validated physics understanding through CWGM activity is to be implemented to system code such as PROCESS and HELIOS.

Highlights in LHD experiment, Invitation to Joint experiment

Extrapolation of physics in depth and width has been continuously progressed in extended parameter regime in LHD. Closed divertor works reasonably (only 1 cryo-pump was installed in the last campaign, though). Validation activity of physics models and large-scale computation has been substantially promoted by utilizing well-documented experimental data. 3D effects in toroidal plasmas such as on viscosity and topology have been clarified through cutting-edge capabilities of LHD. Estimates of the effective mass ratio through simultaneous measurement of GAM and Alfvèn eigenmodes, and of He/H ratio through CXRS has been successfully provided. Schedule of the 17th experiment campaign in FY2013 was shown to call the joint experiment in LHD. The perspectives on the further increase of the ion temperature and on the impurity transport study were discussed.

---

[1] Please visit http://fusionwiki.ciemat.es/wiki/Coordinated_Working_Group

Throughout the meeting, impurity issues were frequently raised, on which enforced programmatic efforts for intensive research is proposed. In the coming meetings, impurity issues will be extensively treated. Your active participation is anticipated.

The 11th CWGM was full of presentations. This is, of course, a clear sign of progress in a range of topics, at one side; but, on the other side, discussions on programmatic collaboration, such as joint experiment, joint papers and database activity, could not be fulfilled to a mature level. Reflecting this situation, the CWGM format was also discussed. Some ideas were raised, such as the prioritization of topics (e.g. convergence on the Stellarator-Heliotron reactor proposal), the promotion of session/task leaders to focus on discussion and collaboration-oriented sessions, or the nomination of a "CWGM-officer" in each institution. The implementation of some of these ideas will be made towards future CWGMs.

The presented materials in previous CWGMs (except for the 1st one, unfortunately) can be reached through either IPP or NIFS CWGM website (designated at the top of this manuscript). A retrospective look at the contents discussed in previous CWGMs should be instructive to consider future direction for this activity. A proposal was made to include the technical capabilities of each experimental group in the fusion-wiki.

Finally, the details of the next CWGM are yet to be discussed. They will be announced once they become available.

Acknowledgements
We are indebted to Mr. R. Klatt (IPP-Greifswald) for his kind support to make the video-conference possible through EFDA-TV. The 11th 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".

12th CWGM

The 12th Coordinated Working Group Meeting (CWGM11) was held on 20 Sep. 2013 at the occasion of Joint 19th International Stellarator-Heliotron Workshop/16th IEA-RFP workshop in Padova, Italy. This was a very brief meeting (for 1.5 hour) after adjourn of workshop. Nevertheless, we could have more than 25 participants from 6 nations. In this very short meeting, we focused on the progress after the CWGM11 (Mar. 2013 at CIEMAT, report is available in Stellarator News, Jun. 2013) and future joint activities in some topics.

The materials presented in the 12th CWGM are available at http://ishcdb.nifs.ac.jp/ and http://fusionwiki.ciemat.es/wiki/Coordinated_Working_Group (→ CWGM12) for those of you having further interests. Below, you will find a breif summary of the meeting.

Inter-machine validation study on transport models has been progressed to get the contents of the joint presentation (IAEA-FEC 2012 by A.Dinklage, IPP) published in Nuclear Fusion (2013). The joint activities have been performed within LHD, TJ-II and W7-AS (materials from published literature). The discharges with comparable ion and electron temperature in medium-to-high density (say, ~ 5×10^{19} m^{-3}) have been gathered to form "step-ladder" datasets towards reactor-relevant collisionality regime. Complete sets of equilibrium (VMEC) and measured profiles (density, temperatures, and radial electric field) have been prepared to perform, as the first phase, neoclassical energy diffusion properties through benchmarked (verified) numerical codes. This has been summarized in Nuclear

Fusion paper. As an extension of this joint activity, systematic study has been performed to investigate non-local feature of neoclassical transport such as by FORTEC-3D code (cf., ISHW2013 poster by S.Satake, NIFS) by utilizing this dataset (in relation to **Flows and viscosity** topics). Gyrokinetic simulations are also anticipated by systematically utilizing this dataset for stimulating validation activity. This dataset will be registered onto the International Stellarator-Heliotron Profile Database, to facilitate the common use. Further joint experiments in LHD by using increased power of ECH are being planned. It was pointed out from D.LopezBruna (CIEMAT) that we should facilitate particle transport issues in addition to currently on-going energy transport issues.

Collaborations on **Flows and viscosity** topics have been promoted in terms of neoclassical viscosity analysis by numerical code (mainly FORTEC-3D). The biasing experiment in LHD has been numerically investigated to successfully predict a relevant biasing voltage for transition. In such a way, experimental validation of numerical code has been progressed. FORTEC-3D is now in preparation to be an "open source". It has been already transferred to CIEMAT (V.L.Velasco) and then used for direct comparison with DKES results (non-local – local). It will be also transferred to HSX (Oct. 2013) to investigate neoclassical viscosity in plasmas with a high poloidal Mach number. Other possible collaborations with, such as IPP (potential asymmetry on a flux surface, high-Z impurity transport by EUTERP, J. M. Garcia-Regana), PPPL (J.K.Park), Heliotron J/TU-Heliac (biasing experiment), and JAEA (RMP effects on JT-60/JT-60SA, M.Honda), are also either in progress or consideration. In such a way, various verification and validation activities are going on in terms of viscosity.

Collaborations have been successfully developed among TJ-II, LHD, H-J on **Alfven Eigen (AE) modes/Energetic particles** topics. Contents of the joint presentation (AE modes in low-shear helical plasmas; IAEA-FEC 2012 by S.Yamamoto, Kyoto U.) are anticipated to be published. Recent highlight topics are the observed effect of ECH/ECCD on AE control in TJ-II (Nuclear Fusion paper by K. Nagaoka, NIFS) and Heliotron J. Mechanism are yet to be clarified, and theoretical explanation will be tried by sharing information on experiment (D.A.Spong, ORNL). The experiment in this regard will be also performed in the coming LHD experimental campaign with participation of E.Ascasibar (CIEMAT). There were also discussions on strong interaction of this topic with the ITPA Energetic Particle (EP) Topical Group (especially, on EP-7: ECH effect on AEs). Next ITPA-EP meeting will be held at CIEMAT in next April, so that contributions from CWGM will be anticipated. Anomalous transport of energetic particles by MHD instabilities are also of common concern among LHD, Heliotron J and TJ-II.

Link to ITPA is also one of main outreaches of CWGM activity in wider fusion community. As introduced in the CWGM11, organizational process of SSOCG (Steady State Operations Coordination Group), co-chaired by T.Mutoh (NIFS) and G.Sips (chair of ITPA Integrated Operation Scenario Topical Group), has been progressed by calling the participation of related IEA (International Energy Agency) Implement Agreements and national laboratories. It has formulated 7 work packages for coordinated actions; one of which (#7) is "Draft a roadmap for developing steady state operation", for which Stellarator-Heliotrons certainly should contribute. Proposals for this issue are anticipated from the S-H community. It is also pointed out it is odd not to have eg., divertor operation in 7 packages. This comment is also transferred to next SSOCG meeting (to be held in Fukuoka, Oct.,2013).

Miscellaneous

It was pointed out from K.Ida (NIFS) that, during the joint ISH-RFP workshop, it has been recognized that magnetic topology (such as stochasticity, magnetic island) affects the impurity transport, and systematic understandings should be urgent issue. On this regard, M.Kobayashi (NIFS) proposed to lead the international collaboration on this issue, through EMC3/EIRENE code, based on discussions with such as DIII-D (E.A.Unterberg) and TEXTOR (O.Schimtz) during the week. S.Satake (NIFS) also proposed to facilitate impurity transport issue in core plasmas through FORTEC-3D code, by utilizing collaboration with EUTERP code. The progress on impurity transport issues by these joint activities are foreseen in coming CWGMs.

Finally, data viewer named “Autoplot” under development in NIFS is introduced and demonstrated from K.Ida as one of tools for facilitating joint experiment in LHD. The details will be available soon. Visitors for LHD experiments are cordially invited to test and raise comments for improvement. Also, Sam Lazerson (PPPL) mentioned that he developed a utility to convert VMEC output files to the old v.6.90 format. Once compiled it will accept any VMEC output which is supported by the LIBSTELL package it was compiled with. These kinds of data handling/numerical tools should facilitate our joint activities.

Next Meeting

At the end of the meeting, there raised a proposal, from K.Nagasaki (Kyoto U.) to hold the next 13th CWGM in Uji, Kyoto in Feb. or Mar. in 2013. Details will be posted in the Stellarator News or sent via e-mails once they become available.

Acknowledgements

We are deeply indebted to Dr. D.Terranova (Consorzio RFX, Italy) and local organizing committee members to allow us to extend the use of the auditorium after adjourn of joint workshop. The 12th 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”, and the grant-in-aid from Future Energy Association (Kyoto).

3 AUSTRALIA

3.1 International collaborations in 2013

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 2013, the new 21 channel plasma density interferometer and high resolution imaging spectrometer were brought into operation 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.

A three view optical emission imaging system was configured to acquire data in synchronism with the MHD signals form the Mirnov coils. Data from the three views allowed limited tomographic reconstruction in the toroidal plane of the camera system using CII light as a proxy for electron density. As the data are in the form of images, there is also data available over 5 degrees each side of that toroidal angle, which will be used to provide additional constraints on the tomographic inversion. The high resolution imaging spectrometer was initially configured for helium line ratio measurements of electron density and temperature. Progress has been made on the new 2 x 200kW RF heating system including remote software control using SMTP protocol and a software tuning iteration system capable of matching to the plasma in one or two iterations. The 21 channel 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.

As part of a longer term strategy that aims for an Australian involvement with ITER, upgrade funding is supporting the development of a prototype 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 2013, operation in excess of $10^{19}m^{-3}$ in helium and hydrogen was achieved, approaching conditions in the divertor of a fusion reactor. Tungsten, its alloys, diamond and carbon samples were exposed to the plasma to observe effects on both the plasma and the impinging plasma.

In 2013 Dr. Greg von Nessi, previously of the Plasma Theory and Modelling Group was appointed as an experimental researcher in the Toroidal Plasma Group.

Multilateral Collaborations

Work on the international collaboration on MHD and configuration studies under the IEA Implementing Agreement for Co-operation in Development of the Stellarator-Heliotron Concept focussed on automatic mode classification, searching for unusual mode structures, and full integration of auxiliary data from Heliotron J and LHD into the new version of the data mining analysis. Dr. Blackwell spent three weeks between LHD and Heliotron-J in collaboration with Prof. S.Sakaibara and Dr. S.Yamamoto. The datamining techniques were able to find additional examples of recently discovered mode locking in LHD. 40,000 shots were examined in one day using the new server installed for international collaborators. On H-1, von Mises clustering was applied to new magnetic field and configuration scans, combining two poloidal arrays and the new 16 element, 3 axis helical arrays. Results were presented at the 19th International Stellarator-Heliotron Workshop, the 23rd International Toki Conference.

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) An imaging MSE system has been installed on the ASDEX-U upgrade and first measurements obtained. The results have been validated against a standard multiple discrete channel polarimeter.

- (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. A similar system has been deployed on the MAST divertor and tomographic reconstruction of divertor flows during L and H modes, and ELM events are being analysed.

Collaborations between ANU, IPP (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. Publications in 2013 covered Thomson Scattering and a force balance validation tool based on the principle of weak observations, which allows multiple forward models to be associated with a single diagnostic observation. In November, Dr von Nessi presented an invited tutorial on Bayesian equilibrium modelling at the “Validation8” workshop on Fusion Data Processing, Validation and Analysis in Ghent, Belgium. With the addition of Dr Clive Michael to the ANU staff, an expert in fast ion plasma diagnostics, we anticipate a wider collaboration 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 for electron temperature and density estimation.

MRxMHD Equilibrium Code: Significant progress was demonstrated in a collaboration between the ANU (R. Dewar, M. Hole, G. Dennis, B. Blackwell, M. McGann, A. Gibson, G. Von Nessi), PPPL (S. Hudson), RFX-mod (Dr Dominique Escande, David Terranova) and CCFE (Prof. Richard Dendy) on the development of a new variational approach

- multi region relaxed MHD (MRxMHD) for calculating 3D plasma equilibria with islands.

In 2013 Em.Prof R.L.Dewar spent 2 weeks at PPPL working with Dr. S.Hudson on theoretical issues related to development the new MRxMHD equilibrium code SPEC. Dr Graham Dennis presented research results at the Sherwood Theory Meeting, and visited PPPL for one week to discuss application of the MRxMHD code SPEC to model RFX-mod, as well as model sawteeth, and spent two weeks at Padua working with RFX-mod staff to constrain the MRxMHD model to data. This work culminated in a Physical Review Letter published in August, led by Dr Dennis, providing a minimum energy explanation of the formation of a helical state with an axis-symmetric boundary. By varying the position of the internal MRxMHD barrier, Poincaré plots of the magnetic field computed by MRxMHD matched those inferred from tomographic inversions of soft x-ray emissivity. Other work published in 2013 included a proof that the infinite interface limit of MRxMHD plasmas reduces identically to ideal MHD. The seminal reference publication for the SPEC code appeared in late November 2012. In wider take-up of this work, the SPEC code was also utilised to model DIIID and MAST plasmas with a resonant magnetic field perturbation, and this work was featured in presentations at the EPS Plasma Physics conference. Also in 2013, Dr Hole presented aspects of this work at an invited talk at the Asia Pacific Physics Conference.

ANU student Mathew McGann completed a PhD on the construction of a Hamilton-Jacobi model to compute the maximum pressure jump that ideal barriers can support in the MRxMHD model. Finally, PhD student Craig Bowie, under the co-supervision of Prof. Richard Dendy, made significant progress calculating avalanche statistics from a sandpile model, which reproduce observed properties of ELMs well.

Collaborations with EU

An existing collaboration between C.Nührenberg and A.Koenies of IPP 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 early 2013, Dr Koenies spent three weeks at the ANU funded by a DAAD grant between the Group of Eight research intensive Australian Universities and German Academic Exchange Service. During this time he assisted with drive calculations of H-1 scenarios and helped PhD student George Bowden formulate his approach to calculation of continuum damping. George subsequently spent three weeks in Greifswald in August, and began implementing changes in CKA-EUTERPE to compute continuum damping with multiple line resonances. A follow-up DAAD grant focusing on continuum damping was successful in 2013, which will support ongoing collaboration exchange in 2014.

Collaborations with JAPAN

In addition to the multilateral datamining collaboration, the following were active in 2013:

R.L.Dewar (Emeritus Prof., Australian National University (ANU)) visited NIFS (H.Sugama) from 4 to 5 Apr., 2013 on recent development of 3D equilibrium issues.

Collaborations with USA

In addition to the multilateral MRxMHD collaboration, and the D3D divertor studies the following were active in 2013:

1) ANU and R. Goulding, J. Harris and T Biewer of ORNL and P. Krstic of Joint Institute of Computational Sciences, U. of Tennessee: 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. This work, undertaken by PhD student Lei Chang, was published in 2013, and formed part of his PhD thesis, submitted in 2013.

Workshops and Conferences

Dr. Boyd Blackwell chaired the Stellarator-Heliotron side of the International Program Committee of the Joint 19th International Stellarator-Heliotron Workshop and 16th IEA Reversed Field Pinch Workshop in Padua in September. Australia was represented by Dr. Graham Dennis, Dr. Greg von Nessi, Prof. R Dewar and Dr. Blackwell.

Dr. Cormac Corr and Dr. Blackwell presented results at the 23rd International Toki conference in November.

Dr Hole represented Australia at the 52nd 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. Dr Hole also presented research results at the EPS Conference on Plasma Physics, and presented an invited talk at the Asia Pacific Physics Conference.

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 2013 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.

Under the expanded collaboration on the MRxMHD project the SPEC code will be applied to MAST with an RMP field, to investigate control of magnetic surfaces between different relaxed regions via external coils. In 2014 the burning plasma project will focus on computing the impact of anisotropy on global modes, and a new postdoc will be appointed to the area. A reciprocal visit from IPP to Australia is also funded to implement kinetic code CKA/EUTERPE on H1 plasmas, and to 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 a new type of MIMO 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 2014.

4 EU

4.1 GERMANY

4.1.1 **International collaborations in 2013**

Collaborations with EU

1) F. Warmer (IPP Greifswald) visited CCFE Culham, 07.01. – 25.01.2013

2) D. Frederic, F. Louche, A. Messiaen, G. Offermanns, J. Ongena, B. Schweer (Laboratory for Plasma Physics LLP – ERM/KMS, Brussels) to IPP Greifswald, 28.01. - 30.01.2013

3) C. Ham (CCFE Culham) to IPP Greifswald, 03.02. – 09.02.2013

4) I. Abel (Oxford University) to IPP Greifswald, 18.02. – 17.03.2013

5) J. Svensson (IPP Greifswald) visited CCFE Culham, 10.02. – 04.05.2013

6) P. Helander (IPP Greifswald) visited Chalmers, Göteborg, 13.03. – 15.03.2013

7) M. Drevlak (IPP Greifswald) visited Chalmers Göteborg, 17.03. – 23.03.2013

8) T. Wauters (Laboratory for Plasma Physics – ERM/KMS, Brussels) to IPP Greifswald, 25.03. - 05.04.2013

9) F. Brochard, G. Bonhomme, G. Bousselin (University Nancy) to IPP Greifswald, 01.04. – 06.04.2013

10) I. Predebon (Padua) to IPP Greifswald, 05.05. – 18.05.2013

11) T. Bird (IPP Greifswald) visited CCFE Culham, 12.05. – 25.05.2013

12) A. Kus (IPP Greifswald) visited CIEMAT, Madrid, 13.05. – 24.05.2013

13) P. Dumortier, J. Ongena, B. Schweer, M. Vervier (Laboratory for Plasma Physics LLP – ERM/KMS, Brussels) to IPP Greifswald, 15.05. - 17.05.2013

14) M. Drevlak (IPP Greifswald) visited Chalmerd Göteborg, 11.06. – 13.06.2013

15) K. Ireneusz (Opole University, Poland) to IPP Greifswald, 16.06. - 21.06.2013

16) H. Smith (IPP Greifswald) visited Chalmers Göteborg, 24.06. – 01.07.2013

17) P. Helander (IPP Greifswald) visited Chalmers Göteborg, 25.06.2013 – 01.07.2013

18) J. Svensson (IPP Greifswald) visited CCFE Culham, 28.06. – 27.07.2013

19) S. Qvarfort (Imperial College London) to IPP Greifswald, 21.07.2013 – 28.09.2013

20) T. Wauters (Laboratory for Plasma Physics – ERM/KMS, Brussels) to IPP Greifswald, 04.08. - 10.08.2013

21) P. Knight (Culham Science Centre, Abingdon) to IPP Greifswald, 11.08. – 17.08.2013

22) A. Zocco (CCFE Culham) to IPP Greifswald, 11.08. – 23.08.2013

23) H. Oosterbeek (University of Technology, Eindhoven) to IPP Greifswald, 15.08. – 17.08.2013

24) P. Cabrera (University of Technology, Eindhoven) to IPP Greifswald, 15.08. – 22.08.2013

25) T. Stoltzfus-Dueck (IPP Greifswald) visited EPFL Lausanne, 25.08. – 30.08.2013

26) M. Beurskens (CCFE Culham) to IPP Greifswald, 26.08. – 28.08.2013

27) D. Dikkinson (University York) to IPP Greifswald, 01.09.– 04.09.2013

28) J. Alcuson Belloso (UC3 Madrid) to IPP Greifswald, 15.09. – 13.12.2013

29) P. Helander (IPP Greifswald) visited Chalmers Göteborg, 26.09. – 27.09.2013

30) A. Mollén (Chalmers Göteborg) to IPP Greifswald, 26.09. – 12.10.2013

31) J. Svensson (IPP Greifswald) visited CCFE Culham, 27.09. – 24.11.2013

32) H. Peraza (UC3 Madrid) to IPP Greifswald, 14.10.2013 – 08.11.2013

33) T. Stoltzfus-Dueck (IPP Greifswald) visited EPFL Lausanne, 30.10.2013 – 07.11.2013

34) S. Kasilov (TU Graz) to IPP Greifswald, 01.11. – 30.11.2013

35) A. Mollén (Chalmers Göteborg) to IPP Greifswald, 07.11.2013 – 20.12.2013

36) M. Kubkowska, W. Figacz, L. Ryc, J. Kacmarczyk (IPPLM) to IPP Greifswald, 25.11. - 28.11.2013

37) T. Szabolics (Wigner RCP) to IPP Greifswald, 18.11. - 29.11.2013

Collaborations with Japan

1) M. Nunami (NIFS) to IPP Greifswald, 12.02. – 14.02.2013

2) S. Murakami (University of Kyoto) to IPP Greifswald, 17.02. – 23.02.2013

3) M. Kobayashi (NIFS) to IPP Greifswald, 03.03. – 17.03.2013

4) S. Kobayashi (Institute of Advanced Energy, Kyoto University) to IPP Greifswald, 10.03. – 15.03.2013

5) Y. Suzuki (NIFS) to IPP Greifswald, 11.03. – 16.03.2013

6) A. Dinklage (IPP Greifswald) visited NIFS, Toki, 25.07. – 09.08.2013

7) S. Masuzaki (NIFS) to IPP Greifswald, 13.08. – 17.08.2013

8) M. Yokoyama (NIFS) to IPP Greifswald, 23.09. – 27.09.2013

9) A. Kus (IPP Greifswald) visited NIFS, Toki, 30.09. – 18.10.2013

10) M. Preynas (IPP Greifswald) visited NIFS, Toki, 28.10. – 08.11.2013

11) M. Preynas (IPP Greifswald) visited Kyoto University (Japan), 11.11. – 22.11.2013

12) J. Geiger (IPP Greifswald) visited NIFS, Toki, 16.11. – 30.11.2013

13) A. Dinklage (IPP Greifswald) visited NIFS, Toki, 25.11. – 29.11.2013

14) M. Yokoyama (NIFS) to IPP Greifswald, 09.12. – 13.12.2013

Collaborations with Russia

1) T. Richert, J. Baldzuhn and R. Vilbrandt (IPP Greifswald) visited the Budker Institute Novosibirsk, 17.02. – 22.02.2013

2) M. Mikhailov (Kurchatov Institute Moscow) to IPP Greifswald, 02.04. – 31.05.2013

3) R. König (IPP Greifswald) visited the graduate school St. Petersburg on Technologies of steady-state diagnostics, 12.05. - 16.05.2013

4) V. Sergeev, E. Gusakov, v. Rozhansky, P. Goncharev, V. Bulanin, V. Gusev, S. Lebedev (RLPAT) to IPP Greifswald, 11.09. - 14.09.2013

5) T. Khusainov (Nizhniy Novgorod) to IPP Greifswald, 21.09. – 29.09.2013

6) Kolmogorov, Belavskiy, Abdrashitov, Drachnichnikov, Selivanov, Shikhovtsev (BINP), 03.11. - 30.11.2013

7) M. Mikhailov (Kurchatov Institute Moscow) to IPP Greifswald, 04.11. – 20.12.2013

Collaborations with Ukraine

n.a.

Collaborations with USA

1) A. Boozer (Columbia University NY) to IPP Greifswald, 06.01. – 19.01.2013

2) G. Wurden (LANL) to IPP Greifswald, 31.03. - 27.04.2013

3) G. Plunk (IPP Greifswald) visited PPPL, 14.04. – 25.04.2013

4) M. L. Reinke (MIT) to IPP Greifswald, 18.04. - 20.04.2013

5) D. Mikkelsen (PPPL) to IPP Greifswald, 28.04. – 04.05.2013

6) R. Ochoukov (MIT) to IPP Greifswald, 12.05. - 15.05.2013

7) G. Wilkie (University Maryland) to IPP Greifswald, 17.06. – 24.08.2013

8) J. Lore, A. Lumsdaine (ORNL) to IPP Greifswald, 24.08. – 30.08.2013

9) A. Lumsdaine, J. Harris, H. Neilson (MIT) to IPP Greifswald, 24.08. - 30.08.2013

10) M. Landreman (University Maryland) to IPP Greifswald, 25.09. – 12.10.2013

11) H. Smith (IPP Greifswald) visited PPPL, 12.10. – 10.11.2013

12) P. Helander (IPP Greifswald) visited PPPL, 26.10. – 02.11.2013

13) G. Plunk (IPP Greifswald) visited PPPL, 26.10. – 05.11.2013

14) D. Gates, S. Lazerson (PPPL) to IPP Greifswald, 08.12. – 14.12.2013

Conference participation

1) M. Lewerentz: MongoDB Workshop and Conference, Berlin, 26.02.2013

2) G. Kuehner: Software Engineering Conference, Aachen (Germany), 26.02. – 01.03.2013

3) E. Stenson: Nonliner Wave and Chaos Workshop 2013, San Diego (USA), 03.03. - 14.03.2013

4) A. Dinklage: 11th CWGM Workshop, Madrid (Spain), 11.03. – 13.03.2013

5) C. Hennig, M. Lewerentz: Business, Technologie und Web Conference, Magdeburg (Germany), 12.03. – 15.03.2013

6) H. Smith: 1st Chalmers Runaway Electron Meeting, Göteborg (Sweden), 15.03. – 23.03.2013

7) G. Plunk, T. Bird: Gyrokinetic Meeting, Vienna, 17.03. – 29.03.2013

8) P. Helander: PCTS Conference, Princeton, 07.04. – 13.04.2013

9) P. Helander: Sherwood Conference, Santa Fe, 14.04. – 18.04.2013

10) P. McNeely, N. Rust, R. Schroeder: Ringberg seminar ITED Te&D, Ringberg am Tegernsee (Germany), 15.04. – 18.04.2013

11) F. Warmer, R.C. Wolf: German DEMO Workshop, Juelich (Germany), 18.04. – 19.04.2013

12) S. Bozhenkov, P. Drewelow, M. Preynas. F. Warmer, R.C. Wolf: Heraeus seminar, Bad Honnef (Germany), 30.04. – 02.05.2013

13) T. Bluhm, J. Schacht: 9th IAEA Technical Meeting on Control, Data, Acquisition and Remote Participation for Fusion Research, Hefei (China), 06.05. – 10.05.2013

14) K. Näckel, U. Stridde: VMware vSphere 5.1-Troubleshooting workshop (VSTS), Hamburg (Germany), 13.05. – 17.05.2013

15) H.P. Laqua: IAEA TM on steady state operation of magnetic fusion devices, Aix en Provence (France), 14.05. – 17.05.2013

16) T. Richert: 25th Symposium on Fusion Engineering, San Francisco (USA), 10.06. - 14.06.2013

17) R. König (IPP Greifswald), German – Polish Workshop, Greifswald (Germany), 20.06. – 21.06.2013

18) H. Braune, V. Erckmann, H.P. Laqua, G. Michel, T. Stange: 25th Joint Russian-German Workshop on ECRH and Gyrotrons, Germany, 24.06. – 29.06.2013

19) V. Erckmann, N. Marushchenko, M. Preynas: 20th Topical Conference on Radio Frequency Power in Plasmas, Sorrento (Italy), 25.06. – 28.06.2013

20) S. Bozhenkov, O. Ford, B. Kemnitz, P. Kornejew, D. Li, T. Sunn Pedersen, M. Preynas, J. Proll, H. Thomsen, D. Zhang: 40th European Physical Society Conference on Plasma Physics, Helsinki (Finland), 01.07. – 05.07.2013

21) H. Braune: IRMMW-THz Conference: Mainz (Germany), 02.09. – 06.09.2013

22) C. Beidler, M. Drevlak, J. Geiger, P. Helander, T. Sunn Pedersen, R. König, C. Nührenberg, J. Nührenberg, J. Riemann, Y. Turkin, F. Warmer, P. Xanthopoulos: Joint 19th ISHW and 16th IEA-RFP, Padova (Italy), 16.09. – 20.09.2013

23) J. Proll: EFTC 2013, Culham (UK), 20.09. – 27.09.2013

24) Y. Feng: 14th PET, Cracow (Poland), 22.09. – 26.09.2013

25) A. Könies, A. Mishchenko: ITPA EP TG Meeting, Beijing (China), 22.09. – 24.09.2013

26) H. Saitoh: Japanese Physical Society, Tokushima (Japan), 23.09. - 28.09.2013

27) A. Dinklage: 8th International Validation Workshop on Data Processing, Analysis and Validation, Ghent (Belgium), 04.11. – 06.11.2013

28) H. P. Laqua, T. Sunn Pedersen, E. Stenson: 55th Annual Meeting of the APS Division of Plasma Physics, Denver (USA), 11.11. – 15.11.2013

29) T. Sunn Pedersen: 18th MHD Control Workshop, Santa Fe (USA), 18.11. - 20.11.2013

30) A. Dinklage, F. Warmer: German DEMO Workshop, Karlsruhe (Germany), 21.11. – 22.11.2013

31) A. Mishchenko: Workshop Modeling Kinetic Aspects of Global MHD Modes, Leiden (The Netherlands), 01.12. – 07.12.2013

32) T. Sunn Pedersen: Monaco ITER International Fusion Energy Days, Monaco, 02.12. - 04.12.2013

33) F. Warmer, R.C. Wolf: IAEA DEMO Programme Workshop, Vienna (Austria), 17.12. – 20.12.2013

Participation in joint projects

International stellarator/heliotron profile data base

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

ITPA diagnostics

1) R. König: San Diego (USA), 04.06. - 07.06.2013

2) R. König: Remote participation ITER IO, Cadarache (France), 15.10. - 18.10.2013

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

n.a.

ITPA Fast Particles

A. Könies: 10th Meeting of the ITPA Energetic Particles Physics Topical Group, Culham (UK), 21.04. – 25.04.2013

A. Könies, A. Mishchenko: 13th IAEA Technical Meeting on Energetic Particles in Magnetic Confinement Systems, Beijing (China), 17.09. – 20.09.2013

4.1.2 Plans for 2014

Planning stellarator/heliotron theory

1) J. Geiger plans to go to NIFS to work on 3D MHD equilibrium problems

2) J. Geiger plans to go to Kyoto University to participate in the Coordinated Working Group Meeting

3) J. Proll plans visit PPPL to collaborate on gyrokinetic theory for stellarators

4) P. Helander will visit Culham for collaboration on 3D MHD stability

5) A. Könies will participate in the ITPA EP Meeting in Madrid

6) A. Könies will visit the IAEA EP Meeting in St. Petersburg

Spectroscopic diagnostics

1) 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.

2) 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.

IR/visible Imaging Diagnostics

n.a.

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 4 - 5 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 database

1) A. Kus plans to visit NIFS within the stellarator-heliotron database cooperation (2 weeks)

2) A. Dinklage plans to visit CIEMAT within the stellarator-heliotron database cooperation (1 week)

3) A. Dinklage plans to attend the CWGM (Kyoto, February 2014)

ITPA confinement and transport

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

Collaboration on ECRH, ECCD and ECE Plans 2014

1) T. Stange 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”.

2) K.Nagasaki (Kyoto University) will visit Greifswald for the Joint research program “Optimization of high power ECRH application to helical fusion plasma confinement systems”

Conference participation 2014

1) M. Dostal, M. Preynas, T. Stange, R.C. Wolf: DPG Frühjahrstagung, Berlin

(Germany), 17.03. – 21.03.2014

2) R. König: 20th Topical Conference High-Temperature Plasma Diagnostics, Atlanta (Georgia, USA), 01.06. – 05.06.2014

3) A. Dinklage, M. Hirsch, H. Laqua, S. Marsen, T. Sunn Pedersen, H. Thomsen, R.C. Wolf, D. Zhang: 41st EPS Conference on Plasma Physics, Berlin (Germany), 23.06. - 27.06.2014

4) H. Laqua: 8th Joint Workshop on ECE and ECRH, Nara (Japan), 22.04. – 25.04.2014.

5) H. Braune, T. Stange: Strong Microwaves: Sources and Applications, Nizhny Novgorod (Russia), (in Comb.with RG-WS), 28.07. - 02.08.2014 tent.

6) D. Chauvin, P. McNeely, F. Warmer, R.C. Wolf: 28th Symposium on Fusion Technology (SOFT), San Sebastian (Spain), 29.09. – 03.10.2014

7) A. Dinklage, M. Jakubowski, R.C. Wolf: 25th Fusion Energy Conference (FEC2014), St. Petersburg (Russia), 13.10. – 18.10.2014

8) T. Sunn Pedersen: 56th Annual Meeting of the APS Division of Plasma Physics, New Orleans (USA), 27.10. – 31.10.2014.

9) M. Jakubowski: QIRT 2014 (Thermography Conference), Bordeaux, 07.07. – 11.07.2014

4.2 SPAIN

4.2.1 **International collaborations in 2013 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 in progress. Secondaries have been successfully detected in 2013 and full operation is foreseen in 2014.

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), 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).

3) Collaboration with Ioffe Institute (Sant Petersburg) on the update of the neutral particle diagnostics in TJ-II. V. Nesenievich visited Ciemat from 6th to 14th July 2013.

Collaborations in Europe

Germany

1. Collaboration agreement (IPP/CIEMAT) in the field of development and operation of diagnostics (reflectometry) and related physics evaluation for W7-X

Portugal

1) C. Silva and I. Nedzelskiy were visiting CIEMAT to continue our collaboration on edge studies (edge turbulence, asymmetries and transport studies and diagnostic development including RFA and probes) during 2013.

2) D. Baião was working on soft x-ray based Te diagnostic for high density plasmas in the TJ-II stellarator (May / November).

3) S. Da-Graça was visiting CIEMAT in May 2013 to continue our collaboration on reflectometry in TJ-II.

Italy

Collaboration with M. Spolaore and the RFXmod 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.

Bulgaria

T. Popov was visiting CIEMAT (June) to investigate non-Maxwellian electron distribution functions in the plasma boundary region and the influence of plasma heating.

Romania

F L Tabares and D Alegre visited the laboratories of Dr Dinescu at Magurele in the frame of the collaboration on tungsten plasma nitriding as PFC for fusion devices.

The Netherlands

D Alegre visted DIFFER and run experiments in Pilot PSI in the frame of collaboration on tungsten nitrides for PFCs.

Collaborations with USA

1) E. Hollmann (USCD) was visiting CIEMAT (1 week, June 2013) working on parallel / radial impurity transport studies and role of Z.

2) I. Calvo spent the month of September, 2012 at MIT to work on gyrokinetic theory. In 2013, he visited MIT from May 6 to June 16.

Collaborations with Ukraine

1) The Heavy Ion Beam Probe team (leaded 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 2013 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 2013).

2) F. Tabarés was visiting IPP Kharkov to discuss the QSPA project and contribute to the wall conditioning of Uragan 2M.

Collaborations with Japan

1) C. Hidalgo was visiting NIFS (October 2013) to study the influence of the electron-ion root transition on low frequency fluctuations and Long Range Correlations in LHD for comparison with previous studies in the TJ-II stellarator.

2) E. Ascasibar was visiting NIFS (November 2013) to study the influence of plasma heating (ECRH) on Alfven Eigenmodes in LHD for comparison with previous experiments in the TJ-II stellarator.

3) Y. Narushima visited CIEMAT during one week (June 2013) 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 March 2013. The visiting scientists involved were: T. Ido, K. Nagaoka and A. Shimizu (NIFS); S. Yamamoto and Ohshima (Kyoto University).

5) D. **L**ópez-Bruna visited NIFS to participate in a joint experiment with the LHD device on magnetic island healing via Electron Cyclotron Current Drive around the island region.

6) J.L. Velasco visited NIFS during April to discuss on the comparison between two neoclassical approaches (FORTEC-3D and DKES) for TJ-II and LHD.

Participation in Joint Projects

Stellarator-Heliotron working groups and ITPA

The 11th and 12th Coordinated Working Group meetings (CWGM) were held in Madrid (March 2013) and Padova (September 2013) to discuss joint activities. Ciemat staff has participated on different topics including L-H physics, momentum and impurity transport, and fast particle physics.

CIEMAT scientists have been directly involved in the ITPA activities along 2013: E. Ascasibar was attending the ITPA Integrated Operational Scenarios meeting (Kyushu, October 2013); C. Hidalgo was attending the ITPA Transport and Confinement meetings (April-2013 Garching, Germany; October-2013 Kyushu, Japan); J. Vega was attending the ITPA Diagnostic meeting.

4.2.2 **Plans for 2014**

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 2014 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 Implementing Agreement for Co-operation in Development of the Stellarator-Heliotron Concept.
2) Plasma diagnostic development and engineering: Diagnostic developments for TJ-II will continue and in a wider context for ITER (with emphasis on reflectometry, VIS-IR spectroscopy) and W7-X (reflectometry, zonal flow and impurity transport physics)
3) Plasma heating (NBI, ECRH) and their role on 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 and density limit).
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 2014:

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. A paper summarizing all the experimental results and outlining the theoretical basis for the observed effects will be sent for publication.

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 gyrokinetic theory.

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.

3) T. Estrada and E. Blanco will visit Greifswald to proceed with the collaboration agreement in the field of development and operation of diagnostics (reflectometry) and related physics evaluation for W7-X

Portugal

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

2) C. Hidalgo will visit IST to study the influence of the isotope effect on plasma confinement and fluctuations in the ISTTOK tokamak

Italy

1) Collaboration with M. Spolaore and the RFXmod team to participate on edge diagnostic development and measurements of electromagnetic turbulence and isotope physics in TJ-II.

2) C. Hidalgo will visit RFXmod to study the influence of the isotope effect on plasma confinement and fluctuations in the RFXmod Reversed Field Pinch.

3) D. López-Bruna will visit RFXmod (1 week) to start a collaboration on MHD stability and transport barrier developments in the proximity of magnetically resonant layers. Bothm theoretical and experimental aspects will be discussed.

4) E. Martines will visit CIEMAT (1 week) to advance on theoretical studies of MHD stability and transport barrier development in magnetically resonant layers.

United Kingdom

I. Calvo will visit the University of Oxford to work on gyrokinetic theory and optimized stellarator concepts.

The Netherlands

Exposure of Li to Magnum PSI plasmas

Romania

Fabrication of WN by plasma techniques

Slovenia

Ammonia production studies in N2/H2 RF plasmas

Collaborations with USA

1) E. Hollmann (USCD) will visit CIEMAT (June 2014) 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 2014.

3) I. Calvo will visit MIT to work on gyrokinetic Theory development.

4) Collaboration with U. Illinois Urbana (Dr Ruzic) on Sn/Li alloys for fusion

Collaborations with Ukraine

1) 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) full operation is foreseen in 2014.

2) F L Tabares. Collaboration on QSPA and PWI issues in Uragan 2M

Collaborations with Japan

1) Collaboration on fast particle physics with Japanes 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) M. Shoji (NIFS) will visit CIEMAT (March) to discuss recent results on stereoscopic dust trajectory measurements, 3-d dust transport simulations and edge transport studies using fast visible cameras in TJ-II.

5) J.L. Velasco will NIFS in order to discuss on possible upgrades to the code FORTEC-3D, so that it can describe better the experimental results of TJ-II and LHD.

International stellarator/heliotron working groups / ITPA

Ciemat staff will participate in the forthcoming CWGM and ITPA meetings to be held along 2014. Next ITPA energetic particles meeting will be held in Madrid (31 March - 4 April).

5 JAPAN

5.1.1 International collaborations by the LHD team at NIFS

Collaborations with Australia

1) R.L.Dewar (Emeritus Prof., Australian National University (ANU)) visited NIFS (H.Sugama) from 4 to 5 Apr., 2013 on recent development of 3D equilibrium issues.

2) B.D.Blackwell (ANU) visited NIFS (S.Sakakibara) from 13 to 15 Nov. 2013 for LHD experiment data analyses and attending 23rd International Toki Conference.

Collaborations with EU

1) S.Imagawa (NIFS) visited IPP-Greifswald in Germany from 15 to 20, January, 2013 to attend the W7-X Commissioning Workshop and to give a presentation entitled "The commissioning and 15 year's operation of LHD".

2) E.Winkler (IPP Greifswald) has stayed in NIFS (T.Morisaki) since 18, January, 2013 and will stay until 31, July, 2014 to develop the helium beam diagnostics which is a newly established collaboration program between LHD and W7-X.

3) M.Kisaki visited Consorzio RFX from 6 Jan. to 8 Feb. 2013 to modify the numerical codes for particle trajectories in N-NBIs on LHD.

4) M.Nunami (NIFS) visited Max-Planck-Institut fuer Plasmaphysik (IPP, Greifswald, Germany) from 11 to 16 February, 2013 to discuss on benchmarking of gyrokinetic turbulence simulations in stellarators. He discussed with Dr. P.Xanthopoulos about the simulation results obtained from GKV-X code and GENE-GIST code.

5) M.Kobayashi (NIFS) visited IPP-Greifswald from 2 to 15, Mar. 2013 to discuss Upgrade of edge plasma Transport simulation code. The code has been adopted To LHD magnetic configuration.

6) T.Ido(NIFS) visited CIEMAT (Madrid, Spain) from 3 to 15 March 2013. He joined experiments performed in TJ-II for investigation of the radial electric field formation, and discussed technical issues on heavy ion beam probes.

7) A.Shimizu (NIFS) visited CIEMAT from 3 to 15, Mar., 2013 to conduct the joint experiments in TJ-II to study AE burst mode.

8) Y.Suzuki (NIFS) visited Max-Plank Institute fuer Plasmaphysik (Greifswald, Germany) and Forschungszentrum Juelich GmbH (Juelich, Germany) from 10th to 21st March 2013 in the international collaboration on 3D MHD equilibrium calculation in stellarator/heliotron and tokamak. These collaboration results were reported at 531st Wilhelm and Else Heraeus Seminar (Badhonef, Germany, May 2013) and Joint 19th ISHW and 16th IEA-RFP workshop (Padova, Italy, Sep. 2013).

9) Y. Narushima visited CIEMAT from 10 to 21, Mar, 2013 for experiment of magnetic island dynamics in TJ-II.

10) K.Mukai (NIFS) visited CIEMAT from 11 to 13, Mar, 2013 to talk about microwave reflectometer and imaging bolometer at CWGM 11 and to progress the collaboration related to these diagnostics.

11) G.Motojima (NIFS) visited Ghent university in Belgium to give presentations of “Helical systems” and “Technology progress and physics achievements in LHD", from 27 to 29 March 2013 within a framework of Erasmus Mundus Program.

12) T. Morisaki (NIFS) participated in the 6th International Workshop on Stochasticity in Fusion Plasmas from 18 to 20, March, 2013 in Juelich. He chaired a discussion session on “Transport and exhaust in helical and island divertors”, in addition to his presentation concerning the density profile formation in the stochastic region in LHD.

13) J.L.Velasco (CIEMAT, Spain) visited NIFS (S.Satake) from 1 to 30 April 2013 to discuss on the benchmark of neoclassical transport simulation codes and application of FORTEC-3D code developed by Satake to analyze TJ-II plasmas.

14) T.Tokuzawa (NIFS) visited Ecole Polytechnique from 20 to 26, Apr, 2013 to attend the workshop of “11th international reflectometry workshop” and give a talk of “Development of multi-channel Doppler reflectometer in LHD and THz pulse diagnostics for higher dense plasma”.

15) T.Mutoh and S.Kubo (NIFS) attended Steady-State Operation Coordination Group meeting held in France from 12 to 19 May. 2013.

16) H.Sugama (NIFS) visited Mediterranean Institute for Advanced Research (IMéRA, Marseille, France) from 1 to 8, June, 2013 to give an invited talk titled "Transport Processes and Entropy Balance in Toroidal Plasmas" at the Workshop on "Turbulence, Transport, and Structures in Magnetized Plasmas". Discussions about theories, simulations, and experimental researches on turbulent transport processes in magnetized plasmas are done.

17) M.Nunami (NIFS) visited Mediterranean Institute for Advanced Research (IMéRA, Marseille, France) from 1 to 8, June, 2013 to give a talk with the title "Turbulent Transport Modeling in Helical Plasmas" at the Workshop on "Turbulence, Transport,

and Structures in Magnetized Plasmas". He discussed about theories, simulations, and experimental researches on turbulent transport physics.

18) Tomohiko Watanabe (NIFS) visited Mediterranean Institute for Advanced Research (IMéRA, Marseille, France) from 1 to 8, June, 2013 to attend the Workshop on "Turbulence, Transport, and Structures in Magnetized Plasmas".

19) G. Kawamura (NIFS) visited Max-Planck IPP Greifswald from 13 May to 29 June, 2013 to promoto collaboration with Dr.Y,Feng on three-dimensional transport simulation of LHD divertor plasma.

20) H V.Antoni and G.Serianni (Consorzio RFX, Italy) visited NIFS (K. Tsumori) from 24 to 28 Jun. 2013 to discuss the future collaboration.

21) .P.Summers, M.O'Mullane, and A.Giunta (Univ. Strathclyde, UK) visited NIFS (I.Murakami and D.Kato) from 15 to 22 June 2013 to participate the ADAS/ADAS-EU Workshop and Advanced Training Course held on June 18-21, 2013, at NIFS. During the workshop they gave lectures on ADAS (Atomic Data and Analysis Structure) and discuss on related topics using atomic data and ADAS with Japanese participants.

22) A.Dinklage (IPP, Germany) visited NIFS (M.Yokoyama) from 29 Jul. to 5 Aug. 2013 to discuss on the joint experiment on LHD for the transport validation collaboration.

23) G.Motojima (NIFS) visited Culham Centre for Fusion Energy from 28 August to 9 September 2013 to join MAST experiments for observing hydrogen pellet ablation.

24) I.Murakami (NIFS) visited the IAEA Headquarters in Vienna, Austria from Sep. 4, 2013 to Sep. 6, 2013 to attend the IAEA Technical Meeting on Technical Aspects of Atomic and Molecular Data Processing and Exchange (22nd Meeting of the Atomic and Molecular Data Centers) to present recent activities on atomic and molecular data and database for fusion science conducted in NIFS, to exchange information and related activities on atomic and molecular data, and to discuss on data validation and other related activities for fusion within the Data Center Network..

25) Y.Suzuki (NIFS) visited Forschungszentrum Juelich GmbH (Juelich, Germany) from 8 to 13 September 2013 in the international collaboration on 3D modeling in the tokamak configuration with the resonant magnetic perturbation field and conceptual design of edge plasma diagnostics in Wendelstein 7-X.

26) K.Saito (NIFS) visited Speyer, Germany from 9 to 11, Sep, 2013 to attend US-EU-JPN RF Heating Technology Workshop.

27) T.Goto (NIFS) visited IPP-Garching from 11 to 13, Sep., 2013 to discuss on the joint work for the BA DEMO design collaborative research about the cost model of fusion reactors.

28) S.Masuzaki (NIFS) visited Berlin Technology Institute and IPP-Greifswald from 13 to 17 Sep., 2013.

29) H.Yamada (NIFS) attended the International Stellarator-Heliotron Workshop (joint with RFP workshop) held in Padova, Italy from 16 to 20 Sep. 2013. During this workshop, he also attended the 42nd Stellarator-Heliotron Executive Committee Meeting. He also visited IPP-Garching from 23 to 25 Sep. to attend IPP Fachbeirat Meeting.

30) M.Yokoyama (NIFS) attended the International Stellarator-Heliotron Workshop (joint with RFP workshop) held in Padova, Italy from 16 to 20 Sep. 2013. During this workshop, he also attended the 42nd Stellarator-Heliotron Executive Committee Meeting. He also visited IPP-Greifswald from 23 to 28 Sep. to extend the International Stellarator-Heliotron Profile Database, and to discuss the application of statistical analyses on it.

31) T.Morisaki (NIFS) participated in the 19th International Stellarator Heliotron Workshop and 16th IEA-RFP Workshop from 16 to 20, September, 2013 in Padova. He made an oral presentation concerning to the radiated power distribution during impurity injection discharges in LHD.

32) M.Kobayashi (NIFS) visited Padova, Italy from 15 to 20, Sep. 2013 to attend the international stellarator/heliotron workshop to give an invited talk concerning Detachment control in LHD.

33) H.Tanaka (NIFS) visited Padova in Italy from 15 to 21, Sep, 2013 to join the 19th ISHW and 16th IEA-RFP workshop.

34) Y. Yoshimura (NIFS) visited Padova, Italy from 15 to 21, Sep, 2013 to participate the Joint 19th ISHW and 16th IEA-RFP workshop, having poster presentation about resent results of ECH activities in LHD.

35) S.Morita, S.Okamura, Y.Takemura, K.Ida, C.Suzuki, T.Seki, R.Seki, K.Nagaoka, H.Takahashi, H.Sugama. K.Ichiguchi, M.Nunami, M.Sato, K.Ogawa, A.Shimizu, H.Tsuchiya, C.Dong and T.Min (NIFS) attended the International Stellarator-Heliotron Workshop (joint with RFP workshop) held in Padova, Italy from 16 to 20 Sep. 2013.

36) T.Goto (NIFS) visited Palau de Congressos de Barcelona (Spain) from 16 to 20, Sep., 2013 to attend 11th International Conference on Fusion Nuclear Technology (ISFNT-11) for a poster presentation.

37) A.Sagara, T.Muroga, H.Chikaraishi, T.Tanaka, H.Tamura, and J.Yagi (NIFS) participated ISFNT-11 in Barcelona from 16 to 20, Sept, 2013 to give an invited talk on helical reactor FFHR design activities.

38) H.Nakanishi (NIFS) visited F4E, Barcelona, Spain from 17 to 19, Sep. 2013 to attend the 2nd Technical Coordination Meeting (TCM-2) on IFERC Remote Experimentation Center (REC). There held the technical discussions for the ITER REC construction activities between EU and Japan. As a collaborating task member for studying fast data transfer technology, some progress report was made.

39) G.Serianni (Consorzio RFX, Italy) visited NIFS (K. Tsumori) 17th Sep. 2013 to discuss on the beam diagnostic experiment performed in the test stand in NIFS.

40) M.Kraus (Max-Planck-Institut fuer Plasmaphysik, Garching, Germany) visited NIFS (contact person: Prof.H.Sugama) from 30 September to 4 October, 2013 to discuss on simulations of plasma turbulence. He gave a seminar titled "Variational Integrators in Plasma Physics".

41) M Kobayashi (NIFS) visited Krakow, Poland from 21 to 27, Sep. 2013 to attend the international workshop on plasma edge theory to give an oral talk concerning Recent code development of edge transport simulation in LHD and first results of Comparison with experiments.

42) G.Kawamura (NIFS) visited Cracow Poland from 24 to 26 September, 2013 to make a poster presentation for the 14th international workshop on Plasma Edge Theory in fusion devices.

43) A.Kus (IPP-Greifswald) visited NIFS (M.Yokoyama) from 30 Sep. to 18 Oct. 2013 to discuss the statistical approach applied for International Stellarator-Heliotron Confinement and Profile Database. He also made a series of seminars on application of statistics.

44) F.Delahaye and N.Moreau (Observatoire de Paris, France) visited NIFS (I.Murakami, H.A.Sakaue, and D.Kato) from Oct. 29, 2013 to Nov. 1, 2013 to participate the forum seminar on atomic and molecular data and their applications held on Oct. 30 – Nov.1, 2013 at NIFS and gave presentation on the Virtual Atomic and Molecular Data Center (VAMDC) project and tutorials on VAMDC. They also discuss how to implement the NIFS Atomic and Molecular Numerical Database to the VAMDC web portal for future collaboration.

45) D.Lopez-Bruna (CIEMAT, Spain) visited NIFS (Y. Narushima) from 29 Oct 2013 to 8 Nov 2013 for experiment of magnetic island control by ECCD in LHD.

46) M.van Berkel (Eindhoven University of Technology) visited NIFS (N. Tamura) from November 21, 2013 (planned until November 20, 2014) with a JSPS Postdoctoral Fellowship to join the LHD experiments regarding a electron heat transport.

47) M.Preynas (IPP-Greifswald) visited NIFS (S.Kubo) from 26 Oct. to 10 Nov. 2013 for participation to ECH experiments in LHD.

48) J.Geiger (Max-Plank Institute fuer Plasmaphysik, Germany) visited NIFS (Y.Suzuki) from 17th to 30th November 2013 to discuss applications of HINT2 code to Wendelstein 7-X.

49) M.Yokoyama (NIFS) visited IPP-Greifswald (A.Kus) from 9 to 13 Dec. 2013 for joint work on statistical analyses for heat diffusivity database in LHD created by TASK3D-a.

50) R.Sakamoto and T.Goto (NIFS) attended the 2nd IAEA DEMO Program workshop held in Vienna, Austria from 16 to 22 Dec. 2013.

Collaborations with Russia

1) I.A.Sharov (St. Petersburg Polytechnical University, Russia) will visit NIFS (S.Sudo and N.Tamura) from January 27th to February 7th, 2014 to discuss a future plan of the collaboration research about a spatial structure of the ablation cloud of the Tracer-Encapsulated Solid Pellet by measuring a Stark broadening with a spatial resolution on LHD.

2) V.Kulygin and A.Spitsyn (Kurchatov Institute) visited NIFS (T.Muroga) on 30 Jan. 2013 for collaborative research.

Collaborations with USA

1) T.Tokuzawa (NIFS) visited UCD from 13 to 18, Jan, 2013 to attend the workshop of “Present status and future direction of electromagnetic-wave imaging diagnostics” and give a talk of “Development of THz pulse wave diagnostics for high-density plasma”.

2) H.Tsuchiya visited University of California Davis from 14 to 16, Jan, 2013, to attend U.S.-Fapan Workshop on "Millimeter Wave Technology and Fusion Plasma Fluctuation Diagnostics".

3) T.Tokuzawa (NIFS) visited UCLA and GA from 11 to 23, Feb, 2013 to implement the Japan / U. S. Cooperation in Fusion Research and Development and discuss about the “microwave diagnostics for turbulent plasma phenomena”.

4) K.Ida (NIFS) attended EU-US Transport Task Force meeting held in Santarosa, USA from 8 to 14 Apr. 2013.

5) K.Ida (NIFS) visited General Atomics from 12 to 18 Apr. 2013, and from 25 Aug. to 1 Sep. 2013 on collaborative research between LHD and DIII-D.

6) H.Yamada (NIFS) visited Princeton Plasma Physics Laboratory for the PPPL Advisory Committee Meeting from 23 to 27, Apr., 2013.

7) F.Waelbroeck (University Texas-Austin) visited NIFS (A.Ishizawa) from 12 to 18 May 2013 for collaborative research on magnetic island in LHD.

8) S.Hudson (PPPL) visited NIFS (Y.Suzuki) from 3 June to 4 September as the guest professor of NIFS. He studied the chaotic coordinate system in non-axisymmetric tori and its application to the LHD. This collaboration result was reported at 23rd International Toki Conference (Toki, Japan, Nov. 2013).

9) M.Yokoyama and Shin Nishimura (NIFS) attended US-Japan JIFT workshop on Present status and prospects of theory and simulation on 3D physics in toroidal plasmas, held in University of Wisconsin-Madison from 3 to 5 Jun. 2013.

10) T.Oishi (NIFS) visited Massachusetts Institute of Technology from 8 to 21 Jun. 2013 for collaborative research.

11) S.Imagawa (NIFS) visited the Sanfrancisco stanford hotel in USA from 9 to 15, June, 2013 to attend the 25th Symposium on Fusion Engineering (SOFE) and to give a presentation entitled "LHD Accomplishments/Plans in Support of Fusion Next-Steps".

12) N.Yanagi (NIFS) attended the 23rd International Conference on Magnet Technology (MT-23) held at Boston, MA, USA, from 14 to 19, July, 2013 to give an oral talk on "Progress of the design of HTS magnet option and R&D activities for the helical fusion demo reactor".

13) N.Yanagi (NIFS) visited Plasma Science and Fusion Center and Francis Bitter Magnet Laboratory of Massachusetts Institute of Technology (MIT) at Cambridge, MA, USA, from 22 to 23, July, 2013 to discuss issues on the development of large current-capacity high-temperature superconductors.

14) K.Ogawa (NIFS) visited PPPL from 14 to 21, Jul. 2013 to discuss on the fast ion profile measurement in LHD and NSTX-U.

15) K.Rule (PPPL), M.King (GA), L.Cadwallader (INL) visited NIFS(K.Nishimura) from 29 July 2013 to 30 July 2013 to observe and to discuss the safety program on experiments in NIFS.

16) N.A.Pablant (PPPL, USA) visited NIFS (S.Morita) from 24 Jul. to 11 Aug. 2013 for collaborative research on XICS measurement in LHD.

17) S.Ohdachi (NIFS) visited General Atomics from 25 Aug. to 1 Sep. 2013 on collaborative research between LHD and DIII-D.

18) C.H.Skinner（PPPL）visited LHD from 1 to 8, Sept, 2013 as the US-J program to demonstrate real time measurement of dusts by using the fine particles analyzer.

19) N.A.Pablant (PPPL) visited NIFS (S.Morita and M.Yokoyama) from 1 Oct to 23 Dec., 2013 to participate 17th LHD experiment campaign, and to conduct XICS measurement and its implementation to integrated transport analyses.

20) S.Satake (NIFS) visited Princeton Plasma Physics Laboratory (U.S.) from 7 to 12 October 2013 to discuss with J. K. Park and K. Kim on the benchmark and application of delta-f neoclassical transport codes to evaluate neoclassical toroidal viscosity in tokamaks with magnetic perturbation. Then, Satake also visited Wisconsin University from 14 to 23 October 2013 to discuss with J. Talmadge and J.Smoniewski on the application of FORTEC-3D neoclassical transport code on HSX configuration, and also discussed on the biasing experiments in LHD and HSX.

21) H.Yamada (NIFS) visited Princeton Plasma Physics Laboratory for the PPPL Advisory Committee Meeting from 5 to 9, Nov., 2013.

22) D.Nishijima (UCSD, US) visited LHD from 9 to 21, Nov, 2013 as the US-J program to measure molybdenum neutral line emission with time in response to divertor exposure.

23) S.Yoshimura (NIFS) visited the Sheraton Denver Downtown Hotel,Denver, CO, USA to attend the 55th Annual Meeting of the APS Division of Plasma Physics from 11 to 15, Nov. 2013. He gave a contributed oral presentation entitled "Spatial structures of intermittent local electron flux in a linear ECR plasma".

24) T.Tokuzawa (NIFS) visited Denver from 10 to 17, Nov, 2013 to attend the APS conference and give an invited talk of “Observation of multi-scale turbulence and non-local transport in LHD plasmas”.

25) A.Shimizu (NIFS) visited University of Wisconsin-Madison from 5 Dec. 2013 to 29 Mar. 2014 to conduct the joint experiment and discuss the cooperation research of density and potential fluctuation measurement in MST and LHD.

26) C.Skinner (PPPL, USA) visited NIFS (N.Ashikawa) from 7th Oct 2013 to 18th Oct 2013 to join experiments of the electrostatic dust detector in LHD.

5.1.2 Plans for 2014

1) M.Shoji (NIFS) visited to CIEMAT from 10 to 16, March, 2014 to discuss on the future international collaboration with CIEMAT on measurement of dust transport using fast framing cameras and the simulation analysis of dusts in the TJ-II stellarator. Participation in dust transport measurements in the TJ-II plasmas will also be done.

2) H.Tanaka (NIFS) will visit IPP-Greifswald on March, 2014 to discuss on the modeling of linear device by EMC3-EIRENE code.

3) H.Tanaka (NIFS) will visit Kanazawa in Japan on May, 2014 to join the 21st international conference on Plasma Surface Interactions 2014.

4) S.Imagawa (NIFS) will visit Charlotte, NC, USA from 21 to 25, February, 2014 to attend the Program Committee meeting for the 2014 Applied Superconductivity Conference.

5) S.Imagawa (NIFS) will visit Charlotte, NC, USA from 10 to 16, August, 2014 to attend the 2014 Applied Superconductivity Conference.

6) J.M.García-Regaña (IPP Greifswald, Germany) will visit NIFS (S. Satake) from 1 to 14 February 2014 to discuss on the implementation of conserved-form linearized collision operator in delta-f simulation and benchmark of neoclassical transport simulation codes.

7) G.Kawamura (NIFS) will visit Forschungszentrum Julich on February to discuss simulation modeling of impurity transport near a divertor plate of LHD.

8) G.Kawamura (NIFS) will make a poster presentation for the 21st international conference on Plasma Surface Interactions held at Kanazawa, Japan

9) Y.Suzuki (NIFS) will visit General Atomics (San Diego, USA) February 2014 to discuss 3D MHD modeling of tokamaks with resonant magnetic perturbation.

These collaboration results will be reported at EPS2014 (Berlin, Germany, Jun. 2014)

10) Y.Suzuki (NIFS) will visit Max-Plank Instituete fuer Plasmaphysik (Greifswald, Germany) and Forschungszentrum Juelich GmbH (Juelich, Germany) in March 2014 to discuss 3D MHD equilibrium calculation of Wendelstein 7-X. These collaboration results will be reported at EPS2014 (Berlin, Germany, Jun. 2014)

5.2.1 International collaborations by the Heliotron J team at Kyoto University

Collaborations with EU

1) M. Prenyas (Postdoctoral fellow, Max-Planck Institute) visited Kyoto University from Nov. 11 to Nov. 22 2013. Concerning plasma breakdown using the second harmonic X-mode ECH in stellarator/heliotron devices, she joined the Heliotron J experiment, and scanned gas pressure, EC power and rotational transform in order to clarify the physics of ECH plasma breakdown. She also presented recent research activities on plasma breakdown using a 2.45GHz and 70GHz microwaves in the WEGA stellarator and future plan in W7-X.

2) S. Yamamoto plans to visit CIEMAT in March 2014. He will join 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 is preparing a paper on the iota dependence of AE and the effect of AE on energetic ion transport taken in TJ-II and Heliotron J.

3) K. Nagasaki have been conducting 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 code was also applied to an interferometer system of Heliotron J to calculate the beam trajectory for designing the transmission system. A paper “Stabilization of energetic-ion-driven MHD modes by ECCD in Heliotron J” was published in Nucl. Fusion 53 (2013), which was a collaboration research work with N. Marushchenko (IPP, Greifswald), T. Estrada (CIEMAT) and G. Weir (U. Wisconsin).

4) Discussions with W7 team (IPP) were kept along the same line as in 2012.

5) Collaborations with CIEMAT were continued along the same lines as in 2012.

Collaborations with Australia

1) B. Blackwell (senior fellow, The Australian National University) visited at Kyoto University from Nov. 25 to Nov. 29, 2013. We have been studying the MHD instabilities including pressure-driven and energetic-ion-driven modes in helical plasmas with 3-D field by using a data mining technique. Recently, his group modified the way to automatically extract the coherent modes from big data and to access the SQL database of H-1 plasmas. We tried to apply the new way to the Heliotron J database with a different structure from H-1.

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

Collaborations with US

1) S. Kobayashi plans to visit the University of Wisconsin, Madison from Dec 9 to Dec 13, 2013. He is proposing an installation of beam emission spectroscopy (BES) diagnostic in a helical device “The Helically Symmetric eXperiment (HSX)” in University of Wisconsin, The BES diagnostic can provide the density fluctuation at a local position where the neutral beam and sightline are intersected, and it has been utilized for the radial profile of the density fluctuation measurements in Heliotron J. During his stay, he will apply a calculation code for BES into HSX, which has been developed in Kyoto Univ., to discuss the candidate sightlines for the BES diagnostic in HSX.

2) K. Nagasaki plans to visit Columbia University and the University of Wisconsin, Madison from Dec. 12 to Dec. 18, 2013. F. Volpe (Columbia University) and K. Nagasaki have been carrying out collaboration research on electron cyclotron heating and current drive for Alfven Eigenmode stabilization. They have been also developing a radiometer system for electron Bernstein waves diagnostic, which is beneficial for electron temperature profile measurement in high-density plasmas. The electron temperature measurement using this diagnostic will start in Heliotron J. K. Nagasaki will discuss reflectometer system and its application to measurement on density profile and density fluctuation with K. Likin and D. Anderson (U. Wisconsin).

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

Collaborations with Ukraine

1) Discussions with Kharkov team about the collaboration in U-2M project were kept along the same line 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 2012.

Others

1) F. Sano, T. Mizuuchi, K. Nagasaki, H. Okada, T. Minami, S. Kobayashi, S. Yamamoto and S. Ohshima attended Joint 19th International Stellarator Heliotron Workshop and 16th IEA-RFP Workshop held at Padova, Italy on September 16-20, 2013. They presented experimental results on Heliotron J and discussed the future collaboration research with researchers from TJ-II, W7-X, H-1 and HSX.

2) A 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.

5.2.2 Plans for 2014

1) C. B. Deng (U. Wisconsin, USA) plans to visit Kyoto University for collaboration

research on the plasma flow and the turbulence. He has been developing a diagnostic for density fluctuation measurement in HSX using a technique of microwave interferometry. He has reported broadband turbulent fluctuation that correlates with plasma density gradient and flow. C.B. Deng and S. Kobayashi will discuss the experimental data of the density fluctuation by BES and plasma flow obtained by CXRS in Heliotron J.

2) Francesco Volpe plans to visit Kyoto University for collaboration research on the EBE diagnostic. He will develop a polarizer to measure the polarization of O-mode emitted from a Heliotron J plasma.

3) 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.

4) 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.

5) 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.

6) 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.

7) NBI start-up using a 2.45GHz microwaves will be performed for high-beta experiments and physics study of plasma production under collaboration with IPP.

8) 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.

9) 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.

10) Particle and heat transport control of edge plasmas will be investigated with regard to divertor optimization.

11) Kyoto University plans to transfer Varian gyrotrons and related components to Oak Ridge National Laboratory.

12) Kyoto University and NIFS plan to make 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.

13) Kyoto University will host the Coordinated Working Group Meeting (CWGM) held at the end of February, 2014.

6 RUSSIA

Collaborations with Germany

1) M. Mikhailov (Kurchatov Institute Moscow) to IPP Greifswald, 02.04. – 31.05.2013

2) H. Braune, V. Erckmann, H.P. Laqua, G. Michel, T. Stange: 25th Joint Russian-German Workshop on ECRH and Gyrotrons, Germany, 24.06. –29.06.2013
3) M. Mikhailov (Kurchatov Institute Moscow) to IPP Greifswald, 04.11. – 20.12.2013

Collaborations with Japan

1) I.A.Sharov (St. Petersburg Polytechnical University, Russia) will visit NIFS (S.Sudo and N.Tamura) from January 27th to February 7th, 2014 to discuss a future plan of the collaboration research about a spatial structure of the ablation cloud of the Tracer-Encapsulated Solid Pellet by measuring a Stark broadening with a spatial resolution on LHD.
2) V.Kulygin and A.Spitsyn (Kurchatov Institute) visited NIFS (T.Muroga) on 30 Jan. 2013 for collaborative research.

Collaboration with Ukraine

1) Dr. L.I. Krupnik and HIBP team (IPP NSC KIPT) in collaboration with Dr. A.V. Melnikov and T-10 team (Kurchatov Institute).
2) Adjustment and calibration of new modification of the multi-sleet (5 sleets) energy analyzer.

3) Providing the experiments directed to investigations of the Geodesic Acoustic modes and their features in the OH and ECRH regimes.

Start collaboration in designing of the probing beam diagnostics to tokamak T-15 (HIBP two complexes and Li^0 atom beam injection).

25th IAEA Fusion Energy Conference (FEC2014) will be held in St. Petersburg from 13 to 18 October 2014.

(Hosted by the Government of the Russian Federation through the State Atomic Energy Corporation ROSATOM)

http://www-pub.iaea.org/iaeameetings/46091/25th-Fusion-Energy-Conference-FEC-2014

7 UKRAINE

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 International collaborations of the NSC KIPT in 2013

Multiple Collaboration

Collaboration of V.V. Nemov, S.V.Kasilov and V.N. Kalyuzhnyj with Technische Universität Graz, Austria Max-Planck-Institut fur Plasmaphtsik, Greifswald. Germany, National Research Centre Kurchatov Institute, Moscow, Russia, and University of Wisconsin, Madison, USA.

Collaboration with CIEMAT

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

1) Heavy Ion Beam Probe diagnostic system (the first one) was upgraded to perform measurements of the different type of the potential oscillations and transport flows on TJ-II:

   - development and tuning new control and data acquisition systems

   - 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 asymmetric structure of plasma potential, behavior of the different kind of Alfven Eigen modes and non - Alfvenic plasma fluctuations in ECRH and NBI plasmas (in with Lithium coated walls). Study of the fluctuation induced transport in core and edge of plasma confinement volume.

3) Adjustment of the all parts of hardware (Injector and Detection systems and control and data acquisition systems) for second Heavy Ion Beam Probe diagnostic on TJ-II stellarators. Tracing of the probing beam.

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) Adjustment and calibration of new modification of the multi-sleet (5 sleets) energy analyzer.

2) Providing the experiments directed to investigations of the Geodesic Acoustic modes and their features in the OH and ECRH regimes.

3) Start collaboration in designing of the probing beam diagnostics to tokamak T-15 (HIBP two complexes and Li0 atom beam injection).

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

V.S. Voitsenya et al. (IPP NSC KIPT) in collaboration with Drs. M. Balden and O. Ogorodnikova (IPP, Garching, Germany) investigated the behavior of specimens of different kind tungsten under long term sputtering.

Conference and other meetings participation

1) V.E. Moiseenko: Meeting on stationary regimes and technological systems of the Thermonuclear Neutron Source (TNS) Moscow, Russia, February 18—19, 2013.

2) V.E. Moiseenko: Seventh IAEA Technical Meeting on "Steady State Operation of Magnetic Fusion Devices". 14-17 May 2013, Aix en Provence, France.

3) V.E. Moiseenko: Joint 19th ISHW and 16th IEA/RFP Workshop, 16-20 September 2013, Padua, Italy (invited).

4) A.S. Kozachek: Joint 19th ISHW and 16th IEA/RFP Workshop, 16-20 September 2013, Padua, Italy (poster).

5) V.S.Voitsenya: The 2nd Research Coordination Meeting on Utilization of the Network of Small Magnetic Confinement Fusion Devices for Mainstream Fusion Research, IAEA, Vienna, Austria,19-22 March 2013.

7.2 Plans for 2014

Collaboration with Technische universität Graz, Austria

V.V.Nemov, S.V.Kasilov and V.N.Kalyuzhnyj will continue collaboration aiming the study of collisionless high energy ion losses in a stellarator-mirror plasma neutron source.

Collaboration with Spain (CIEMAT, Madrid)

1) Designing, manufacturing and installation new modification of the emitter-extraction system in the probing beam injector if the first HIBP system.
2) Tuning and start experiments with the second HIBP system.
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.
4) Collaboration in improvement of efficiency of wall conditioning procedure in the stellarator U-2M

Collaboration with Russian Kurchatov Institute, Moscow

1) Joint development two kinds of the probing beam diagnostics for new tokamak T-15. (HIBP two systems and Injection of the neutral atoms Li0 and Na0.
2) Investigation of the nature Tl ion emission and increase intensity of the probing beam.
   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.

The tasks to be solved at IPP NSC KIPT in 2014

1) Providing boronization procedure at U-2M torsatron.
2) Investigation of the processes in divertor of the Uragan-3M torsatron accompanying H-like mode transition.
3) Investigation of the nature and behavior of high energy particles in Uragan-3M RF plasma.
4) Investigations on development of RF wall conditioning in Uragan-2M.
5) Comparative experiments on RF plasma production and heating in Uragan-2M device in regular torsatron configuration and in the stellarator-mirror hybrid.
6) Commissioning of two-polarized interferometer for diagnosing plasma in U-3M and multi-frequency reflectometry for Uragan-2M plasmas.
7) Investigations of RF-discharge plasma in U-3M torsatron with controlled gas puffing.
8) Investigation of MHD fluctuations in the RF-produced plasmas in Uragan-3M torsatron.
9) Investigation of parametric instability at the periphery of plasma confinement volume in Uragan-3M.
10) Clearing up the mechanism of suppression of run-away electrons when DC voltage is applied to

8 UNITED STATES

8.1 International collaborations in 2013

Collaborations with EU

1) D.Mikkelsen (PPPL) visited IPP-Greifswald from April 29 to May 7 to continue benchmarking calculations for LHD ion-ITB plasma comparing GS2 and GENE.

2) D.Gates (PPPL) visited IPP Greifswald from July 10-29 to develop collaborations including a recently approved project to build an X-ray diagnostic for the W7-X project.

3) D.T.Anderson (UW-Madison) participated in the review of the W7X TDU Scraper Element on 8/28/2013.

4) H.Zohm (IPP Garching) spent fall Semester in 2013 at UW-Madison as a visiting professor.

5) N.Pablant (PPPL) visited IPP-Greifswald from September 23-26 to discuss design issues with the XICS diagnostic being planned for the W7-X facility.

6) V.Q.Mas (CIEMAT) visited PPPL on October 3 to give a talk on novel approaches for stellarator construction.

7) H.Smith (IPP-Greifswald) visited PPPL from October 14 through November 9 to work on a theoretical model of stochastic heating by Alfven wave turbulence.

8) D.Gates, S.Lazerson, and H.Neilson (PPPL) visited IPP-Greifswald December

9-13 to discuss PPPL-IPP collaborations on W7-X. Topics included Equilibrium reconstruction, stellarator turbulence optimization, diagnostic development and use of the US built trim coils.

Collaborations with Japan

1) K.Tanaka(NIFS) visited PPPL from February 18 to March 7. He conveyed experimental data for new ion-ITB shot from LHD. Carried out GS2 calculations for new ion-ITB shot from LHD (for heat transport studies) and for a JT-60U ELMy H mode shot (to study particle transport). Learned procedures for grid generation using new grid generator, and for convergence testing.

2) M.Nunami (NIFS) visited PPPL from February 25 to March 5 to make benchmark calculations and comparison figures for LHD ion-ITB shot.

3) N.Pablant (PPPL) visited NIFS from March 18 to April 8 to work on data analysis of High Te regimes for experiments run on LHD in 2012.

4) S.Kobayashi (Kyoto Univ.) visited HSX 3/26/2013 to discuss collaborations and will again visit HSX 12/9-13/2013 to discuss collaborations on CHERS and BES

5) M.Zarnstorff (PPPL) visited NIFS on 29 March 2013 to collaborate with S.Ohdachi and S.Okamura on optimization of high beta plasmas in LHD.

6) K.Ida (NIFS) visited General Atomics from 12 to 18 Apr. 2013, and from 25 Aug. to 1 Sep. 2013 on collaborative research between LHD and DIII-D.

7) H.Yamada (NIFS) visited Princeton Plasma Physics Laboratory for the PPPL Advisory Committee Meeting from 23 to 27, Apr., 2013.

8) UW-Madison (C.Hegna in charge) hosted the US-Japan JIFT Workshop on "Theory and Simulation of 3-D physics in Stellarators/Heliotrons and RFPs" in Madison, June 3-5

9) T.Oishi (NIFS) visited Massachusetts Institute of Technology from 8 to 21 Jun. 2013 for collaborative research.

10) S.Hudson (PPPL) visited NIFS from June 10 to September 10 in the role of visiting professor where he worked with Yasuhiro Suzuki on the HINT2 code.

11) K.Ogawa (NIFS) visited PPPL from 14 to 21, Jul. 2013 to discuss on the fast ion profile measurement in LHD and NSTX-U.

12) K.Rule (PPPL, USA), M.King (GA, USA), L.Cadwallader (INL, USA) visited NIFS(K.Nishimura) from 29 July 2013 to 30 July 2013 to observe and to discuss the safety program on experiments in NIFS.

13) N.A.Pablant (PPPL) visited NIFS (S.Morita) from 24 Jul. to 11 Aug. 2013 for collaborative research on XICS measurement in LHD.

14) S.Murakami (Kyoto Univ.) visited HSX in July for collaborations with the GNET

code for modeling ICRH driven fluxes in HSX

15) S.Ohdachi (NIFS) visited General Atomics from 25 Aug. to 1 Sep. 2013 on collaborative research between LHD and DIII-D.

16) N.Pablant (PPPL) visited NIFS from October 1 to December 23 to operate the US built XICS diagnostic on LHD, to participate in the 2013 LHD run and to further analyze data from the 2012 run.

17) C.Skinner (PPPL) visited NIFS in Oct 7 - 18. The dust detector was installed on Oct. 11 on LHD, and measurements were started from Oct. 16.

18) S.Satake (NIFS) visited PPPL from September 7 to 11 to work with J.K.Park and S.Lazerson on stellarator modeling using FORTEC3D.

19) S.Satake (NIFS) visited HSX 10/14-18/2013 to collaborate on HSX calculations using the FORTEC-3D code to analyze plasma electric fields near the helical ion resonance.

20) H.Yamada (NIFS) visited Princeton Plasma Physics Laboratory for the PPPL Advisory Committee Meeting from 5 to 9, Nov., 2013.

21) D.Nishijima (UCSD, US) visited LHD from 9 to 21, Nov, 2013 as the US-J program to measure molybdenum neutral line emission with time in response to divertor exposure.

22) A.Shimizu (NIFS) visited University of Wisconsin-Madison from 5 Dec. 2013 to 29 Mar. 2014 to conduct the joint experiment and discuss the cooperation research of density and potential fluctuation measurement in MST and LHD.

23) K.Nagasaki (Kyoto Univ.) visited HSX from Dec. 16 to Dec. 18, 2013 to discuss collaborations on ECE pulse propagation measurements and EBW heating.

24) M.Zarnstorff (PPPL) visited NIFS on Dec. 9 to participate in the external review committee on LHD.

25) M.Zarnstorff (PPPL) visited NIFS December 10-13 to collaborate with S.Ohdachi and S.Okamura on optimization of high beta plasmas in LHD.

APPENDICES: TECHNICAL REPORTS ON 2013 ACTIVITIES

APPENDIX 1: HIGHLIGHTS OF LHD EXPERIMENTS

In 2013, the Large Helical Device (LHD) comes to its 17th experimental campaign (Plasma experiment: from 2 Oct. to 25 Dec. 2013). Progress being made in this experimental campaign will be reported after it finishes and detailed analyses are conducted.

Record parameters newly achieved in 2012 are summarized as follows; ion temperature (Ti) of 7.3 keV at density (ne) of 1.2×10^{19} m^{-3}, electron temperature (Te) of 13.5 keV at ne of 1.4×10^{19} m^{-3}, and steady state operation of 18 min 55 sec at the heating power of 1 MW (producing plasma with 2.5 keV/9.4×10^{18} m^{-3}). These extensions of plasma parameters have been achieved not only by the upgrade of machine capability but also by the improvement of operation scenario. A large number of opportunities for diversified domestic and international collaborations have been produced as well.

It has been found that repeated 10s-ICRF discharges are effective to reduce recycling through wall conditioning, and then effectively increase the NBI power deposition at core region even without an increase of available NBI power. Along with the recognized ion heat confinement improvement, this operation scenario has become the standard for high-Ti plasma production. Newly installed 1MW-level 154 GHz gyrotron (developed under the bi-lateral collaborative framework with Tsukuba University) has contributed to increase available total ECH power to more than 4 MW. With this upgrade of ECH systems, Te has been increased in higher density regime (in the range of10^{19} m^{-3}) than before. Although high-Ti and high-Te plasma production has been conducted separately, integration of simultaneous increase of Ti and Te has been one of targets in 16th and 17th campaigns due to this overlapping of density regime.

Diagnostics capabilities have also been extended. One of them is the X-ray imaging crystal spectrometer (XICS, based on collaboration between NIFS and PPPL), for measuring full profiles of ion-temperature without beam injection. It has made ion transport analyses in pure ECH plasmas possible, and the diagnosed data are implemented into the integrated transport analysis suite, TASK3D-a. Another example is the fast charge exchange recombination spectroscopy (CXRS), which has revealed abrupt change of Ti profiles (flattening) and the toroidal flow profiles (damped) in accordance to the stochastization of magnetic field in the core region.

Such performance extension and progressing physics understandings in LHD were presented in the 19th International Stellarator-Heliotron Workshop (joint with 16th IEA RFP Workshop) held in Padova, Italy in Sep. 2013. Progresses in 2013 will be presented in many occasions in 2014, such as 25th IAEA Fusion Energy Conference (St. Petersburg, Oct. 2014).

APPENDIX 2: 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. The collaboration with ERM/KMS and FZJ for the ICRH has been further intensified. FZJ/TEC, the Wigner Institute Budapest, and the Polish Association are strongly involved in the development of diagnostics. The cooperation with KIT on the ECRH system is running well. The collaboration with KIT regarding the design and construction of the current leads for the superconducting coils has been successfully concluded with the final delivery of the last current leads. The collaboration with Polish research institutes is running smoothly. IPJ Swierk is continuing its work on the neutral beam injection system for W7-X. Various diagnostic systems are being developed by Polish institutes and universities.

Within the collaboration with US laboratories, PPPL provides the trim coils for W7-X and the respective power supplies. All five coils and the power supplies have already been delivered to Greifswald. ORNL develops the design for the divertor scraper element, an additional high-heat-flux component to protect the divertor during plasma start-up with high power discharges. LANL is developing a fast infrared camera system for divertor monitoring.

- Wendelstein 7-X construction (preferential support activity)

The restructuring of operational phase 1 in two separate phases OP 1.1 and OP 1.2 and the revised plan of the KiP-assembly over three installations phases are now the working basis for the project schedule. Milestone 27 “Completion of Cryostat”, which marks the start of commissioning, is now the top priority of the project.

Magnet system

The current leads for the superconducting coil system have been completely assembled on three modules, the preparation for the remaining four CL-pairs is progressing according to the plan. All CLs are already installed in their final position. The power supplies for the five trim coils provided by PPPL have been delivered to the IPP; four coils have already been installed on W7-X.

In-vessel components

The manufacturing of the in-vessel components is proceeding according to schedule. All components necessary for the first phase of operation (OP 1.1) are now available for assembly in Greifswald. The production of the remaining components for OP 1.2 is being pursued with high priority. The detailed design and manufacturing for the high-heat-flux divertor for OP 2 is making good progress; currently, the construction efforts are focused on mountability.

Assembly

All five magnet modules have been installed within their respective cryostat module and are positioned on the machine base. The module connections in the plasma vessel and the outer vessel have been completed and the last ports have been welded. With this milestone achieved, the outer vessel is now in its final shape and the plasma vessel, as one of the major components of W7-X, has been completed.

The assembly of the in-vessel-components is being pursued with considerable effort. Continuous improvements in the work preparation, increased specialization and additional resources are applied, to further mitigate the risk to the assembly schedule. However, the actual process times still exceed the updated targets. A significant improvement to the situation is expected at the end of the year, when all assembly steps have been performed at least once.

Periphery

The Thomson-bridge and the heavy-duty structure have been installed in the torus hall. An additional multiple use structure is currently being manufactured by Fantini, Italy. The installation of the central torus hall platform is progressing according to plan. The assembly of the cooling circuits is pursued with high priority, the time critical manufacturing of the central ring line is under close monitoring. Also time critical is the assembly of the vacuum systems. The planning and manufacturing of electrical cabinets has been reorganized and put under central coordination for improved efficiency.

Device Control, Data Acquisition and Communication (CoDaC)

The CoDaC master plan for device control and data acquisition has been reviewed with close scrutiny and has subsequently been revised with a strong focus on priorities for commissioning and the restructured operations schedule. Additional staff resources have been allocated, and tasks and responsibilities have been reassigned. The revised planning has restored the necessary conditions that the prerequisites for commissioning and first operations will be met in time.

Commissioning and Operations Planning

The new sub-division “Operations” and the recently appointed task force “Master Plan for Commissioning” now coordinate the necessary efforts on the path to the first plasma. A commissioning plan has been drafted for the first components and can now be used as a model for other components. With personal safety and device safety as non-negotiable elements of the commissioning strategy, the development of safety procedures for the parallel assembly and commissioning phase is making good progress.

- Wendelstein 7-X physics

Wendelstein 7-X heating systems (preferential support activity)

Electron Cyclotron Resonance Heating (Project PMW at KIT)

The gyrotrons SN5 and SN7 have failed the factory acceptance test (FAT) and need to be refurbished. The malfunctions could be clearly identified and a repair plan was

elaborated. The gyrotron SN6 was delivered to KIT in October 2013 has passed the FAT. The delivery of SN2i is scheduled for Jan 2014.
The data acquisition system for the ECRH has been commissioned successfully. The update of the local control system has been completed. The integration of the ECRH into the W7-X control system was specified. The related segment programs have been developed and tested for two gyrotrons exemplarily.
The ECA-diagnostic, which measures the transmitted ECRH-power, has been installed in the W7-X vessel. The video immersion tubes for the ECRH launchers are currently being fabricated. The sniffer-diagnostic, which measures the ECRH stray radiation in all five W7-X modules, has been designed.
The ECRH towers have been completely equipped and installed at their final position in the experimental hall.
The design of the remote steering launcher is progressing. This advanced concept bases on precisely manufactured corrugated rectangular waveguides. Their manufacturing procedure has been developed and first waveguide parts have been built successfully.

Ion Cyclotron Resonance Heating (ICRH)

It is planned to install one double strap antenna on W7-X at the latest for OP 2. The design of the antenna and the design of the RF system is planned to be done within the framework of a collaboration with TEC. The details of the RF system are still to be finalized, however, it has already been concluded that the RF generators of TEXTOR can be used on W7-X, since they cover a part of the desired frequency bands for ICRF heating. In addition, the conceptual design of the antenna including outside support structures has been nearly completed by TEC. This antenna will be fully water cooled to be able to operate in 30-minute ECRH discharges and can be moved radially by about 15 cm to optimize the RF transmission into the plasma for all reference magnetic field configurations of W7-X.

Neutral Beam Injection (NBI)

The pre-assembly of the neutral beam injector boxes in the NBI hall is nearing completion with almost all exterior mechanical parts installed. The cabling of the sensors and controls has started. The magnetic shielding is complete for both boxes. The assembly inside the torus hall is ongoing, the cooling water pipes are being installed and the components for making the connection between the injector box and torus beam duct are under manufacture.

The collaboration with the Polish institute NCBJ Swierk was highly successful. The cooling water system was installed and commissioned in the NBI hall basement. Final tests of the cooling water system require that the torus hall pipe work is finished and will occur after the injector boxes are installed in the Torus Hall. The injector boxes gate-valves complete with heating system have been delivered and are installed on the boxes. The two ion reflection magnets were delivered this year and are in storage. Lastly the injector box support structures complete with hydraulic position adjustment system have been delivered to Greifswald and are awaiting installation in the Torus Hall (scheduled for summer 2014).

A test facility for the AC driven Ti sublimation pumps has been completed and tests indicate that it should be possible to operate the pumps even in the presence of the

W7-X magnetic field. Procurement of the necessary AC power supplies has begun. The motors for moving the calorimeter up and down have been delivered to Greifswald, are currently being wired and will be tested soon. Work has started on the control system for two sub components: the secondary vacuum system and the gas system.

- Wendelstein 7-X diagnostics

Limited capacities are still a critical factor for diagnostics development. Therefore, all diagnostics activities are governed by the priorities derived from the schedule for commissioning and operations. It is expected that an adequate set of start-up diagnostics will be ready for the first plasma operation in 2015. In fact, many diagnostics are now being fabricated and prepared for installation. Below follows a status report for selected key diagnostics.

Neutron counters

The design of the neutron counters and the in-vessel railway system for calibration has been completed and manufacturing of both has started.

Single Channel Dispersion interferometer

The two granite plates that constitute the vertical interferometer bench together with their massive support structure from Al-profiles were set up in the laboratory and the transfer to their concrete base plate in the torus hall is being prepared. All optical components of the laboratory table top setup were transferred to the vertical optical bench for the torus hall installation. For this, the fastening elements were modified, an alignment procedure for the vertical interferometer established and water cooling for the most critical optical components installed, to allow for steady state operation of the diagnostic

Thomson scattering

The main support structure for the Thomson scattering system has been manufactured and erected in the torus hall. The in-vessel port protection and water cooled shutter have been installed and the trial installations of the immersion tubes for the observation systems were completed successfully.

Diagnostic neutral beam injector (RuDi-X)

The final injector tests at BINP in Novosibirsk were finished successfully. The injector has been delivered to IPP and re-assembled in a test stand. The injector has reached its performance parameters so that the final acceptance tests can be completed by mid Dec. this year. The completion of the control system will be done by IPP before installation of the injector in the experimental hall in 2015.

HEXOS

The HEXOS-spectrometer has been brought from TEXTOR to IPP and installed at its final location on W7-X.

Infrared and visible diagnostic observation systems

The 8 simplified infrared/H-alpha immersion tubes have been manufactured and delivered to IPP. Following an international tender, the contract for the long pulse compatible IR/visible endoscopes for divertor thermography has been placed and the conceptual design review been successfully completed. The international tender for the two IR cameras for the two endoscopes for OP1.2 has also been completed and the contract has been placed.

In-vessel magnetic diagnostics

The first diamagnetic loop for the bean shaped plane has been installed in the plasma vessel. The diamagnetic loop with the compensation loops for the triangular plane has been handed over to assembly. 46 of 124 Mirnov coils have been fixed on heat shield elements, installed in the plasma vessel and connected to the in-vessel signal cables. An additional 47 coils have been prepared for installation. The first continuous and another segmented Rogowski coils have been installed in the plasma vessel and two more segmented Rogowski coils are being manufactured.

Edge helium beam diagnostic

FZJ has manufactured, tested and delivered the first of two piezo-valve based thermal He-beams which will be installed in W7-X in Jan. 2014.

X-ray imaging crystal spectrometer (XICS) and Multi-purpose manipulator

Two new diagnostic projects were approved, the XICS system which will be provided by PPPL, USA, and the torus midplane multi-purpose manipulator (initially with a Langmuir probe head) which will be provided by FZ-Jülich.

APPENDIX 3: TECHNICAL REPORT ON TJ-II ACTIVITIES

TJ-II is a medium-size Heliac-type stellarator operating at low magnetic shear. The results achieved in the TJ-II stellarator during 2013 were obtained in plasmas created and heated by Electron Cyclotron Resonance Heating (ECRH) (2 x 300 kW gyrotrons, at 53.2 GHz, 2nd harmonic, X-mode polarisation) and Neutral Beam Injection (NBI). Two beams of 700 kW port-through (H0) power at 34 kV, were injected on TJ-II. Recently the TJ-II research programme has been focussed in the understanding of the plasma flow dynamics in relationship with TJ-II confinement transitions and isotope effect physics, impurity transport, stability and fast particle physics. All the results have been obtained under Li coated wall conditions, which allows us to achieve density control reaching high density plasmas and transition to H−mode. Biasing experiments of carbon and lithium limiters were initiated. New enhanced Confinement modes were identified.

L-H transition physics. Dedicated experiments have been carried out to investigate the spectral structure of the turbulence-flow interaction during the predator-prey process. The measurements indicate that intermediate turbulence scales ($k_\perp$: 6-11 cm-1) dominate the energy transfer of the predator-prey process. Recently, bicoherence analysis has been done to study the non-linear coupling between turbulence and flows in the proximity of the L-H. The bicoherence is associated with a specific wave number range (the intermediate one) and in all cases, is due to the interaction between high frequencies and a rather low frequency.

MHD activity and transport. A thorough survey of MHD activity in TJ-II NBI plasmas has revealed that typical activity, much in common with tokamak phenomenology like sawtoothing or internal crashes, happens close to the magnetically resonant layers (i.e., low order rational values of the rotational transform). The phenomenon of transport barrier formation and the existence of intermediate states between the L- and H-modes of confinement seem included in this phenomenology, which has motivated a line of research where MHD activity around magnetic resonances is presumed as the cornerstone of the experimental findings; in other words, a possible way of stability and confinement control is envisaged based on externally controlling the magnetic configuration.

Isotope effect. We have investigated and compared the properties of local turbulence and long-range correlations (LRC) in Hydrogen and Deuterium plasmas in the TEXTOR tokamak and TJ-II stellarator. Experimental findings have shown a systematic increasing in the amplitude of LRC during the transition from H to D dominated plasmas in the TEXTOR tokamak but not in (low density ECRH) TJ-II plasmas. These results provide the first direct experimental evidence of the importance of multi-scale physics for unravelling the physics of the isotope effect in fusion plasmas. These observations provide a guideline for further studies to unravel the physics of the isotope effect in fusion plasmas. Exchange of H/D on hot Li walls has been investigated and ways to remove the higher mass isotope were addressed.

Impurity transport. Experimental observations in TJ-II high density NBI plasmas display a clear deviation of the spatial variation of the parallel bootstrap C-VI flow, measured by means of CXRS, from an incompressible pattern at some radial locations. In addition, asymmetries in plasma potential have been investigated in the plasma edge region of the TJ-II stellarator. Using the magnitude of long-range correlation to label magnetic flux surfaces, we have provided direct experimental evidence of poloidal / toroidal variation of the electrostatic potential.

Fast particle physics. The properties of fast ion confinement have also been investigated from both theoretical and experimental points of view, including the appearance of Alfven modes and the dynamics of the fast ions created by Neutral Beam Injection. TJ-II is a unique device for the studies of ECRH effect on AEs thanks its diagnostic capabilities and the flexible ECRH and NBI systems. The chirping amplitude is reduced when on-axis injection is performed. If the ECH power is further increased (two gyrotrons) the AE amplitude appears to be drastically decreased and the mode can be eventually stabilised. This result suggests a possible tool for AE control in reactor relevant conditions.

Plasma stability. The influence of magnetic well scan on the effective plasma confinement radius has been investigated, showing that the edge shear layer moves accordingly to the position of the vacuum Last Closed Flux Surface (LCFS). Thus, although according to Mercier criterion, magnetic well is the main stabilizing mechanism in TJ-II stellarator, magnetic well does not affect the radial location of plasma confinement radius.

Plasma Wall Interactions. Total H retention and power load handling characteristics of LLL were explored. A new LLL will be installed and operated in TJ-II in 2014.

APPENDIX 4: TECHNICAL REPORT ON HELIOTRON J ACTIVITIES

Particle fuelling control, effects of the magnetic configuration on toroidal flow, fast ion confinement, bulk thermal confinement, MHD stability and edge fluctuation have been investigated in a flexible helical-axis heliotron, Heliotron J, with special regard to the optimization study of helical systems with spatial magnetic-axis and vacuum magnetic well. To attain the drift optimization of the L=1 helical-axis heliotron, the bumpiness control is essential to reduce the neoclassical transport (or the effective helical ripple). The experiments have been performed in several configurations. The Heliotron J activities in 2013 are summarized as follows:

1) Several gas-fuelling techniques have been developed to expand the plasma operational region in Heliotron J into higher-density domain ($n_e > 5 \times 10^{19}$ m^{-3}) under NBI heating ($P_{inj.}$<1.5MW). When the plasma density is increased with conventional gas-puff fuelling (GPF), the stored energy Wp becomes saturated or decreased at a density level, probably due to the edge cooling caused by excess neutrals. Local fuelling with a short pulse of supersonic molecular beam injection (SMBI) can increase the core plasma density with avoiding the confinement degradation. In addition, another way to higher-density and higher stored-energy region is opened by using a high-intensity gas-puff fuelling (HIGP). High density (>10^{20} m^{-3}) NBI-only plasmas are achieved with T_{e0} and T_{i0} ~ 0.2-0.3 keV by the combination of low □ configuration and HIGP. The density fluctuation is reduced in accordance with the sudden drop of the H□/D□ emission intensity, a shear is established at the peripheral region.

2) The role of the toroidal mirror ripple on the parallel flow has been investigated in the neutral-beam-injection (NBI) heated plasmas of Heliotron J. The parallel flow velocity at the core region, which is measured with a charge exchange recombination spectroscopy (CXRS), depends on the ripple strength. In a co-directed NBI of 0.5MW injection power, the flow velocity at high mirror ripple case is measured to be around 4km/s in the co-direction, 2-3 times smaller than that for the standard configuration. In the peripheral region (r/a~0.6), on the contrary, the parallel flow velocity (2-3km/s) in the co-directed NBI is not sensitive to the ripple strength. A Fokker-Planck analysis shows that the external torque at the peripheral region is small, indicating spontaneous rotation. In the standard ripple configuration with the counter-directed NBI case, a reversal of the flow velocity to the co-direction is observed in the peripheral (r/a>0.6) region. The neoclassical transport analysis using moment method by taking the effect of the external torque input into account shows that for both the ripple configurations, the parallel flow velocities by the measurement results are almost consistent with the neoclassical transport analysis. From the neoclassical transport analysis, the radial thermodynamic force is a candidate to explain the spontaneous rotation.

3) The MHD instabilities destabilized by the energetic ions are observed in NBI-heated plasmas of Heliotron J and TJ-II. In order to identify the observed mode, we have compared the experimental results and numerical simulations by STELLGAP and AE3D code where we took into account three-dimensional magnetic configuration which leads to both the poloidal and toroidal mode coupling of each shear Alfvén wave. In Heliotron J, we only found the GAE, whose frequency lies just below the shear Alfvén spectra of m=2/n=1. The frequency,

mode number and radial structure of calculated GAE agree with the experimental results obtained from Mirnov coils and soft X-ray (SX) measurements. On the other hand, in TJ-II, we found GAEs and HAEs, whose frequency is similar to the observed frequencies, in simulations. Moreover, we also observed energetic particle modes (EPMs). The observed EPMs are localized at plasma edge region obtained from beam emission spectroscopy (BES) and SX. Iota scan experiments in both devices show that the GAE frequency increases with an increase of iota. This is the same tendency found in the numerical simulations.

4) We have attempted to control the mode amplitude of the observed EPMs by the change of plasma current induced by ECCD. EPMs with n=0, 1 and 2 are observed in NBI-heated plasma in the range of n_e < $1x10^{19}$ (m^{-3}). When $N_{//}$ is changed in order to induce ECCD, the mode amplitude of the observed EPMs with n=0 and 1 is decreased as the EC induced plasma current increases. The mode amplitude is strongly linked to the magnetic shear because the continuum damping rate, which is the main damping mechanism of EPMs, is related to the magnetic shear. In TJ-II, on the other hand, when ECH is applied into NBI-heated plasmas, the initially continuous AEs display bursting behaviour with rapid frequency chirping. The mode amplitude of the bursting AEs is weaker than that of the continuous AEs. The ECH power and deposition profile affect the mode amplitude of the observed bursting AEs. A candidate to explain the mitigation of AE by ECH in TJ-II is the increment of Landau and/or collisional damping whose damping date is related to the electron temperature.

5) Influence of energetic particle driven instability on edge plasma fluctuation and potential structure was discovered. A characteristic MHD fluctuation at ~60 kHz was observed, which is a kind of AE having a radially broad structure with poloidal/toroidal mode number m/n~1/1 and is propagating in ion diamagnetic drift direction. Influence of the MHD on broadband fluctuations was found when the mode appears continuously without intermittency, which was clarified using bi-coherence analysis applied to the probe signals at 4mm inside the LCFS (ρ= 0.93). Envelope analysis also shows that the MHD mode modulates the particle flux evaluated from ion saturation current and floating potential measured with the Langmuir probes. Low-frequency response of potential synchronized with MHD burst events were observed around LCFS only when intermittent MHD bursts appear, which induces change of radial electric field. The structural change is found to be symmetric in toroidal/poloidal directions from the correlation analysis using several probes. These experimental observations imply that such MHD instabilities may have influence on the confinement property of bulk plasma through nonlinear process and/or change of electric field structure.

6) Beam emission spectroscopy (BES) has been used to measure local density fluctuations. A BES system in heliotron J views 16 view lines (r/a=0.11-0.97) in the radial direction, and is being extend into the poloidal direction which enables us to measure 2-D density fluctuations. The initial four-points (two points in the radial direction and two points in the poloidal directions) measurement shows that a density fluctuation with a peak at 5-30 kHz has been observed at the core region (r/a=0.2-0.3). A two-point correlation method which provides the □-k fluctuation spectrum indicates that the radial wavenumber is $-0.5<k_r<0.5$ cm^{-1}, and the poloidal wavenumber is $-1 < k_{\square} < 0.5$ cm^{-1}, meaning that the fluctuation propagates in the

ion diamagnetic direction.

7) Fast ion velocity distribution in the low density region has been investigated using fast protons generated by ICRF minority heating. The effective temperature of minority proton in on-axis heating was higher than that in the inner-side heating; however, the bulk deuteron temperature in on-axis heating was lower. It is not consistent with the minority heating scheme since most of rf input power is absorbed by minority ions. Fast ion's distribution is occasionally localized in real space, and there is a loss region in velocity space in the high energy area. The effective temperature of fast minority ions and the bulk ion temperature in the high bumpiness are highest among three configurations. In the high bumpiness case only, the minority effective temperature profile is asymmetrical against the magnetic axis. In the larger horizontal angle, the profile is symmetrical against the magnetic axis as in the other two bumpiness configurations. For the bulk ion temperature profile, no asymmetry is observed in all the bumpiness configurations. In the Monte-Carlo simulation, generation of fast ions in the high bumpiness configuration is largest among three configurations. Calculated pitch angle dependence for the volume averaged fast ions agrees with the experimental result of the on-axis line of sight.

8) A perpendicular-view fast video camera has been installed in Heliotron J to observe the behaviour of filamentary structures of edge plasma turbulence across the last closed flux surface (LCFS). Supersonic molecular-beam injection (SMBI) can greatly increase the edge H_α emission; hence, we used the high imaging rate and shutter speed of the camera to capture the behaviour of the fast propagating filamentary structures. A high-pass fast Fourier transform filter on the time dimension was adopted to extract the fluctuation component from the raw data for each pixel. The motion of the filamentary structures was clearly visible when we applied an amplitude threshold to identify the intense structures. In addition, a time-resolved 2D cross-correlation technique was adopted to estimate the poloidal phase velocity of turbulence. The motion direction was found to be reversed dramatically just after an SMBI pulse.

9) To study peripheral plasma turbulence/fluctuation in Heliotron J, a hybrid probe system (Langmuir probes and magnetic probes), a fast camera and a gas puff system were installed at the same toroidal section. Fast camera views the location of the probe system, so that the probe system yields the time evolution of the turbulence/fluctuation while the camera images the spatial profile of those. Gas puff at the same toroidal section was used to control the plasma density and simultaneous gas puff imaging technique. Using this combined system the blob (filamentary structure) associated with magnetic fluctuation was found in Heliotron J at the first time. The other fluctuation without magnetic fluctuation was also observed at another experiment. This combination measurement enables us to distinguish MHD activity and electro-static activity.

10) An improved confinement could be successfully achieved by an electrode biasing in the Heliotron J. The increases of ne and ne Te, the decrease of the potential fluctuation and the formation of strong negative Er were observed. The nonlinearity in the plasma resistance was found in the transition region and the clear hysteresis was observed. An intermittent transition phenomenon was found in the marginal-biasing condition. In the discharge, forward and backward transition

repetitively occurred. This is considered due to the spontaneous change of the normalized poloidal torque around the transition threshold.

11) Two new laser diagnostics, an FIR laser interferometer and a Nd:YAG Thomson scattering system, are developing for the high-density plasma profile measurement in Heliotron J. The FIR laser interferometer consists of an HCN laser (λ=337μm),a super-rotating grating, an interferometer system, and Schottky diode detectors. The interferometer has a high time resolution (> 1μsec), because the super-rotating grating can modulate a local beam by a frequency of ~1.45MHz, of which stability is higher than that of the two lasers method. We also develop a new reconstruction method of the density profile from line averaged density values using a GCV method under the complicate magnetic flux surface structure of Heliotron J. The Nd:YAG Thomson scattering system has 25 spatial points with ~10mm resolution by interference polychromators and an optical fiber bundle. The system can measure a wide range of an electron temperature and density (Te: 10eV − 10keV, under $n_e > 5\times10^{18}m^{-3}$). Two high repetition Nd:YAG lasers (> 550mJ@50Hz) realize the measurement of the plasma profile with ~10ms time intervals.

12) Followed by the development of the multi-channel far-infrared (FIR) laser interferometer a new density reconstruction method is investigated for obtaining electron density profiles from line-integrated density. It is based on a regularization technique with aid of singular value decomposition (SVD), and a generalized cross-validation (GCV) function is used to optimize the regularization parameter. The reconstruction results show that the reconstructed profiles can be improved by considering the beam position arrangement carefully and properly.

13) To deepen the understanding of the configuration effects on confinement, the following new diagnostics are being designed and/or installed; an improved CXRS system for the measurement of ion temperature and toroidal rotation, VUV spectrometer, upgraded Langmuir probes, magnetic probes and fluctuation measurement by using an SX tomography and a reflectometer for density fluctuation. Advanced wall conditioning method using a Li coating is under development.

APPENDIX 5: SUMMARIES OF THE INSTITUTE OF PLASMA PHYSICS OF THE NSC KIPT, KHARKOV

Plasma Theory

1) On the Parameters of the Stellarator as a Neutron Source for a Subcritical Reactor. The possibility of developing a stellarator-based neutron source designed for the nuclear reaction initiation in the blanket of hybrid reactor was studied. An analogue of the LHD stellarator design, with linear dimensions increased by a factor of 1.5 was taken for the magnetic system. Plasma parameters and the DT mixture fusion power were calculated using the space-time numerical code under the assumption of the neoclassical transport in the ambipolarity regime. It was shown that using the 10 MW plasma heating sources it is possible to obtain the DT fusion power of one-to-two tens MW

2) Calculations of collisionless high energy particle losses for optimized stellarators in real space coordinates. Lately a code has been worked out for a direct computation of charged particle collisionless losses in stellarators in real space coordinates in contrast to corresponding codes in magnetic coordinates (V.V. Nemov, et al, 38th EPS Conference on Plasma Phys, Strasbourg, 27 June-1 July 2011, P1.113). The code solves the guiding center drift equations in presence of magnetic islands and stochastic regions of the magnetic configuration. Now this code is applied for studyштп life time of α-particles in the configurations of quasi-helically symmetric stellarators, quasi-isodynamic stellarator, and inward shifted configurations of heliotron/torsatron devices. Calculations are performed for the configurations adapted to reactor plasma parameters for the magnetic field produced by the coil systems or expanded into the toroidal harmonic functions.
As to quasi-helically symmetric stellarators idealized configuration QHS (J. Nuehrenberg, R. Zille, Phys. Lett. A 129, 113 (1988)) and practically realized configuration HSX (F.S.B. Anderson, et al, Fusion Technol. 27, 273 (1995)) are considered. The results show that for HSX the particle losses are essentially larger than for QHS. However for HSX the particle confinement can be improved to a level comparable to that in QHS by increasing the number of twisted coils and corresponding decreasing an amplitude of additional small magnetic field ripples. In the case of quasi-isodynamic stellarator it is found that for the configuration obtained by an additional optimization of the configuration of the work by M.I.Mikhailov et al, Plasma Phys. Rep. 35, 529 (2009) collisionless particles are confined up to about 2/5 of the minor radius. For the configurations of heliotron/torsatron devices CHS, LHD and Uragan-3M it is found that for inward shifted configurations a delay of collisionless particle losses takes place as compared to the rate of losses in standard configurations.

3) Evaluation of non-ambipolar particle fluxes driven by non-resonant magnetic perturbations in a tokamak. Non-ambipolar particle fluxes (radial plasma currents) are responsible for the phenomenon of neoclassical toroidal plasma viscosity, which is driven in a tokamak by the external non-resonant magnetic perturbations coming from the toroidal field ripples, error fields, ELM mitigation coils etc. Such perturbations are well described by ideal MHD theory. Equilibria given by this theory can be viewed as stellarator equilibria with a very small portion of the non-axisymmetric field. This facilitates the use of existing results of stellarator transport theory for the computation of non-ambipolar particle fluxes. These results have been obtained with certain model simplifications, such as simplified geometry and the use of model collision operators. At IPP Kharkov and ITP/CP TU-Graz, a numerical approach has been developed using on the basis of the gyrokinetic equation solver NEO-2, which uses no such simplifications beside the assumption that perturbations are small enough such that particle motion within the perturbed flux surface is only weakly affected by non-axisymmetric harmonics of the perturbation field in Boozer coordinates (quasilinear approach). Nevertheless, such regimes occupy a significant part of the parameter domain of modern tokamaks. Numerical results from NEO-2 stay in good agreement with results of most analytical approaches and NEO code in the regimes where those approaches are valid. Currently the benchmarking with DKES code is under way (in cooperation with IPP Greifswald). In the near future, the quasilinear version of NEO-2 code will be applied for the modelling of intrinsic toroidal plasma rotation in ASDEX-Upgrade tokamak

4) Computation of the Spitzer function in a stellarator. The generalized Spitzer function is an important part of current drive calculations. In the long mean free path regime this function can be effectively computed by bounce averaged methods. In regimes with finite collisionality, the evaluation of this function for stellarator configurations is rather difficult. Often it is performed using simplified collision models and/or simplified configurations. During the previous years, the kinetic equation solver NEO-2 has been developed at IPP Kharkov and ITP/CP TU-Graz to solve, in particular, the Spitzer problem in tokamaks and stellarators. This code does not use any simplifying assumptions for the collision operator or for the device geometry. Prior to recent developments, NEO-2 was mainly used for computation of mono-energetic neoclassical transport coefficients in stellarators and for computation of the generalized Spitzer function in tokamaks. This restriction to tokamak geometry was mainly due to long computing times. Recently a parallel version of NEO-2 code has been developed. This parallel version is now highly suitable to treat the Spitzer problem in stellarators for a wide range of collisionalities, because computation speed has a scaling with number of processors which is close to linear (up to 15 processors have been tested so far). Code has been tested for standard configuration of W-7X and stays in good agreement with fully relativistic bounce-averaged kinetic equation solver SYNCH in case of mild temperatures and low plasma collisionality. In future, code will be applied for ECCD computations in W-7X what would require building an interface for the interpolation of the generalized Spitzer function between the flux surfaces and taking into account relativistic effects in the collision operator which might be important at high plasma temperatures.

5) Neutronic calculations of a stellarator-mirror hybrid. The MCNPX numerical code has been used to model the neutron transport in a stellarator-mirror fusion-fission reactor. The purpose of this paper is to determine a principal design of the fission mantle which fits to the neutron source and to calculate the leakage of neutrons through the outer surface of the fission reactor. In the calculation model, the fission reactor part has a cylindrical shape with an inner radius 1.658 m and a 4 m length. The fuel is the “standard” spent nuclear fuel with isotopic composition of the spent nuclear fuel from PWR after uranium-238 removal. Inside the fission reactor core is a vacuum chamber with a radius 0.5 m containing a 4 m long hot plasma producing fusion neutrons. Such a scheme of the subcritical system, but in a bigger scale, is proposed and studied earlier by K.Noack. To sustain the hot ion plasma which is responsible for the fusion neutron production, neutral beam injection to the mirror part of the device is considered. In such a scheme, some fusion neutrons are generated outside the reactor core near the injection point. This part of the plasma column is suggested to be surrounded by a vessel filled with borated water to absorb the fusion neutrons. Calculation results for the radial leakage of neutrons through the mantle surface of the fission reactor are presented. These calculations predict that the power released with neutrons from the reactor to outer space would be small and will not exceed the value of 5.7 kW when the reactor thermal power is 1 GW_{th}. Heat load on the first wall and the neutron spectrum in the blanket are calculated.

6) Research on stellarator-mirror fission-fusion hybrid. The development of a stellarator-mirror fission-fusion hybrid concept is reviewed. The hybrid comprises a fusion neutron source and a powerful sub-critical fast fission core. The hybrid is aimed at transmutation of spent nuclear fuel and safe fission energy production. In its fusion part neutrons are generated in deuterium-tritium plasma confined magnetically in a stellarator-type system. A stellarator is chosen since it provides steady-state operation (for a year or more) of the device and offers relatively good confinement for a warm background plasma. The hot minority tritium ions can be sustained in the plasma by radio-frequency heating or neutral beam injection (NBI). Since high energy ions are poorly confined in stellarators, it is proposed to embed into the stellarator a mirror trap with lower magnetic field. Because of the mirror trapping effect, the hot ion motion is restricted to the mirror part of the device. Basing on kinetic calculations, the energy balance for such a system is analysed. In a power plant scale, the plasma part of the considered hybrid machine is rather compact with a size comparable to existing fusion devices. A small scale experimental device could be built in for a proof-of-principle purpose, and may even have a positive power output. Neutron calculations have been performed with the MCNPX code, and the principal design of the reactor part is based on the earlier made developments. Neutron outflux at different outer parts of the reactor is calculated. Numerical simulations have also been performed on the structure of a magnetic field created by the magnetic system of a combined plasma trap. The calculations predict existence of closed magnetic surfaces under certain conditions. An implementation of a closed magnetic surface configuration for the stellarator-mirror system seems therefore feasible.

7) VHF discharges for wall conditioning at the Uragan-2M torsatron. The very high frequency (VHF) discharge for wall conditioning with hydrogen atoms is studied. It is driven by the RF power at frequencies ~140 MHz, higher than usually used in ICRF. For wall conditioning a special small size antenna is designed. The antenna is aimed to excite the slow wave that is damped via electron collisions with neutral gas. The wave excitation is modeled using a 1D numerical code. In the experiment, the discharge parameters are studied as functions of confining magnetic field and gas pressure. The Langmuir probe measurements give the radial profiles of plasma density and electron temperature. The discharge is volumetric: plasma occupies whole confinement volume and even steps out at the edge. The characteristic value of plasma density is 10^{10} cm^{-3}, electron temperature varies in the range 3-10 eV. The temperature values of probe measurements are compatible with the results of optical diagnostics. Such parameters of discharge are favourable for wall conditioning in hydrogen. The discharge parameters did not reveal any sensitive dependence on neutral gas pressure and the toroidal magnetic field. The mass-spectrometry of the residual gas is used for monitoring the wall conditioning effect of the VHF discharge.

8) Theoretical studies of RF heating in the Uragan-3M torsatron continued with taking into account real 3D distribution of plasma density and magnetic field. It was revealed that ion cyclotron zone crosses the frame type antenna. The important role of slow mode, which penetrates through the most part of plasma volume, was emphasized.

Plasma Experiment

1) Energy spectrum of charge exchange atoms at Uragan-3M. For the low plasma density the FT antenna regime (n_e=(1-2)x$10^{12}cm^{-3}$) the linear semi-logarithmic dependence of CXA atoms was observed in the 0.5-2.5 keV energy range, what gives a good reason to say about the "ion temperature" for this group of ions. The anisotropy of this ion temperature was observed: 0.5-0.6 keV based on the vertical NPA data and 0.2-0.3 keV based on tangential NPA data for the isotropic calibration in the energy distribution analyses. Application of the anisotropic calibrations causes only quantitative modification of the temperatures, but does not change the main results about the temperature anisotropy. The lower parallel temperature (as compared to the perpendicular one) indicates that during such mode of FTA discharges the RF power deposition to the perpendicular ion energy predominates in comparison with deposition to the longitudinal energy. A rather short confinement time of these ions restricts collisional isotropization of the ion energy. This assumption is qualitatively supported by the fact that almost isotropic ion temperature is observed within the $n_e \geq 4 \cdot 10^{12}$ cm^{-3} discharges.

2) Heavy Ion Beam Probe diagnostics was installed at the U-2M. The U-2M stellarator (a = 0.22 m, R = 1.7 m, B_0 = 0.4–2.4 T, $P_{ICR} \leq$ 0.5 MW) is now equipped with HIBP diagnostics with parameters: ion energy – up to 150 keV (first stage), primary ion current – up to 200 μA, type ion – cesium (in future, thallium ions can be used), energy analyzer has a collector block with 2 slits (8 collectors). Calculating trajectories of the primary Tl^+ and Cs^+ beams were obtained for existing entrance and exit diagnostic ports and for two values of the confinement magnetic field: B_0 = 0.5÷0.8 T (first stage device operation) and 0,8÷2.4 T (second one). The HIBP measurable radial range is 0.1<r/a<1. The necessary energy of Cs^+ ion beam for existing magnetic field (0.5 T) is 90 keV and Tl^+ probing ion beam of 150 and 800 keV respectively for the two next steps of stellarator operation (0.8÷2.0 T). Energy electrostatic analyzer has energy resolution $\Delta E/E \sim 10^{-4}$ and operation voltage up to 40 kV. Ion beam injector was tested at the test device to ion beam energy of 90 keV, beam current – 160 μA.

3) Heavy Ion Beam Probe diagnostics was upgraded at TJ-II. TJ-II stellarator (a = 0.22 m, R = 1.5 m, B_0 = 1 T, $P_{ECRH} \leq$ 0.6 MW, P_{NB}I ≤ 1 MW) is equipped now with two systems of HIBP diagnostics. Second HIBP-II is located at 90 degrees toroidally relative to the first HIBP-I, what makes possible to study the long-range correlations in plasma potential and density, toroidal and poloidal structure of plasma turbulence and instability modes. Energy of probing beams – up to 150 keV, primary ion current – up to 150 μA, ion type – cesium. New design HIBP-II energy analyzers consists of 2 blocks with 5 slits (20 collectors each. Test start of HIBP-II is carried out in 2013.
Energy analyzer of the HIBP-I diagnostic has been equipped with two sleets (8 collectors) for two point measurements to study directly with a good spatial (1 cm) and temporal (10 μs) resolution the plasma electric potential and density, as well as their fluctuations, poloidal component of electric field $E_p = (\varphi 1 - \varphi 2) / \Delta r$ [V/cm] and to extract radial turbulent particle flux. The time evolution of the radial profiles from Low Field Side (LFS) to the High Field Side (HFS) (-1<r<1) are observed in a single shot (HIBP-I). Transition from the positive to negative electric potential and electric field is smooth.

4) Installation of sensors for study the MHD activity outside the plasma confinement volume. In the l=3 torsatron Uragan-3M, with natural helical divertor configuration, plasma is generated and heated by the use of RF-power at $\omega \approx 0.8\ \omega_{ci}$. Plasma parameters realizing in the device allow to operate in the mode of low collision frequencies (“banana” mode). This mode is characterized by the presence of significant toroidal currents (up to 2 kA), having, as it is assumed, a bootstrap-current nature. Due to this, some MHD activity can be presented. To get information about low-frequency (<100 kHz) plasma magnetic turbulence, the set of 15 stationary magnetic sensors, i.e., typical Mirnov coils, was used. The sensors are installed in one poloidal cross section outside the confinement volume, at the radius 18 cm (inner radius of the helical winding casings is 19 cm, average plasma radius ~12 cm). They can detect fluctuations up to 150 kHz. At the first stage the auto spectra of magnetic oscillations and the spectra of the coherence and phase shift between difference pairs of magnetic sensors were measured. It was found that the main spectra and significant correlation between the magnetic fluctuations from the neighboring sensors range up to 40 kHz. At the same time, the coherence from the more distant sensors is essential only in the vicinity of certain frequencies allocated at ~5 and ~30 kHz. At present the scheme is under preparation which will give possibility of simultaneous recording of signals from all 15 sensors and thus to obtain the information on the spatial distribution of the poloidal magnetic field turbulence.

5) Two regimes of RF plasma produced by frame antenna. At the U-3M torsatron the main efforts were focused on optimization of operation of the frame type RF antenna to produce a target hydrogen plasma for the three-half-turn antenna; both antennas operate in the Alfven resonance frequency range. Depending on the magnitude of RF power P_{FT} fed to the FT antenna (below it will be characterized by the anode voltage of the RF oscillator U_{FT}) and initial hydrogen pressure p_{H2} in the U-3M tank, it is possible to implement two distinct regimes of the FT antenna discharge with different behavior of the line averaged electron density, ECE radiation temperature T_e, particle confinement time, and plasma loss to the divertor region. For B_ϕ = 0.7 T the corresponding operational frequency of the FT antenna is f = 8.8 MHz and these two operational regimes differ by the values of RF oscillator anode voltage of ≈5.5 kV and ≈8.0 kV, which correspond to the P_{FT} power of 45 kW and 95 kW, respectively.
The RF discharge with lower U_{FT} is characterized by higher plasma density (≤ $6x10^{12}$ cm^{-3}) and rather low T_e (200-300 eV), whereas with higher RF power T_e reaches ~800 eV but density drops to ≤ $2x10^{12}$ cm^{-3}, and the L-mode-like transition occurs triggered by the loss of high energy ions. This range of RF power for each regime to be realized is a function of the initial gas pressure.

6) H_2 molecules are the main source of plasma in the U-3M with confinement volume ~1/200 of the vacuum vessel volume. Measurements of spatial and spectral intensity distribution of Balmer series lines (H_α, H_β, H_γ , H_δ and H_ε) during frame antenna operation in U-3M torsatron were carried out at the poloidal cross section remote from the FT antenna and plotted as the function of principal quantum number for two regimes defined in the previous section. The results demonstrate that the H atom radiation comes from the volume limited by the last closed magnetic surface (LCFS), what means that the processes associated with the excitation of hydrogen atoms occur within the plasma confinement volume. It was found that for anode voltage U_{FT}≈5.5 kV demonstrate that the intensities of Balmer series lines do follow the law typical for the process of dissociation of hydrogen molecules with formation of excited states: $H_2 + e \rightarrow H^*(n) + H + e$, (n ≥ 2). Estimated from similar data for U_{FT}≈8.0 kV the fraction of molecular process at the active phase of the discharge is close to 80%. This fraction does almost attain the value ≈100% within ≈3 ms after RF shutdown, what is determined by the molecular hydrogen flow from the buffer volume into the confined plasma with still high enough stored energy (i.e., the conditions resemble those realized at the U_{FT}≈5.5 kV case).

7) “Ultimate” configurations of the l=1, m=13 torsatron and the “Vint-20” torsatron as a possibility of creating a tandem stellarator-mirror trap hybrid system. The paper is concerned with numerical investigation of various magnetic configurations of a single-pole toroidal **l**=1, m=13 “ultimate” torsatron having a low aspect ratio A_h=4.345 and the modulation factors (-0.23)≤ α ≤ 0.71 (K=1, β=0) of the helix law $-m\varphi=\theta-\alpha K\sin\theta - \beta K\sin 2\theta$ (φ is toroidal and θ is poloidal angles). The extremums of the basic properties of closed magnetic surfaces as functions of the coefficient α in the neighborhood of α≈0.4, as well as the structures of the edge magnetic field (substructures of virtual current) and the separatrix of the helical divertor have been first determined for the **l**=1, m=13 “ultimate” torsatrons and the “Vint-20” torsatron. Unusual positions of the separatrix X-points in the cross sections for 1/4- and 3/4- magnetic field periods have been identified. The formula that takes into account the modulation factor α of the helix law was first derived to determine the average vertical magnetic field on the geometrical axis of the torus. Three variants of the calculated configurations demonstrate the influence of the modulation factor β on the volume and properties of the magnetic surfaces. The analysis of these variants has shown that the magnetic configurations of the l=1, m=13 torsatron with a low aspect ratio appear rather resistant to the perturbations of the helical winding as it is laid on the torus with relative geometrical variations within ~0.015-0.02. The undertaken studies point to a new interesting possibility of **l**=1 torsatron application with a potential usefulness. Now one may state that the **l**=1 "ultimate" torsatron with a low aspect ratio and a large number of magnetic field periods presents an example of the easiest natural tandem stellarator-mirror trap hybrid system. It should be noted that this possibility, based on the peculiarities of the **l**=1 torsatron and its magnetic surface properties, can be successfully put into practice unlike the other two hypothetic possibilities of creating compact torus-stellarator and mirror trap-stellarator hybrid configurations, published in literature.

8) Research on stellarator-mirror fission-fusion hybrid. In the fission-fusion hybrid neutrons are generated in deuterium-tritium plasma confined magnetically in a stellarator-type system. The hot minority tritium ions are formed locally at an embedded into the stellarator magnetic mirror with lower magnetic field by radiofrequency heating or neutral beam injection (NBI). The localization of the hot sloshing ions and the neutron generating zone to the mirror part allows one to surround the neutron generating zone by a local fission blanket. Energy balance calculations for such a system are performed. NBI is studied numerically for the above-mentioned hybrid scheme. Neutron calculations have been made with the MCNPX code. Numerical simulations have also been carried out on the structure of a magnetic field created by the magnetic system of a combined plasma trap. Existence of a closed magnetic surface configuration for the stellarator-mirror system was prooved in a model experiment at Uragan-2M device.

9) Parametrical instability excitation. The study of parametrical instability excitation and its evolution was provided near the edge of plasma confinement volume in U-3M torsatron during plasma creation and heating by introducing RF-power at the frequency near the ion-cyclotron resonance frequency. The instability excitation thresholds together with the spatial coordinate of the maximal amplitude for the higher frequency harmonics were determined. Taking into account the results of previous theoretical modeling it was concluded that the observed instability is connected with generation of Bernstein modes. The phenomenon of harmonic decomposition was observed at the first and second harmonics, what indicates on intense nonlinear processes when RF power is introduced into the U-3M plasma.

10) The interaction of runaway electrons with plasma of RF-discharge. Investigation of the dynamics of runaway electrons in the U-3M torsatron was continued. The dependences of the runaway electrons flow intensity on the pressure of working gas (hydrogen) and the effect of the flow decay due to the interaction with the RF-plasma were studied experimentally. Besides the dynamics of X-Ray and synchrotron radiation (from data via ECE 3X, 57-75 GHz) were also monitored during the variation of RF power introduced into the plasma confinement volume on the stage of occurrence of the runaway electrons flows. To measure the runaway electrons current the Rogowski coil was installed and absolutely calibrated.

11) Controlling runaway electrons flow to improve the discharge performance. The new methods of stimulation of the runaway electrons flow by increasing the density of charged particles (electrons) at the stage of the flow occurrence were developed. To stimulate the reproducible start of RF-discharge some initial ionization using the runaway electrons flow was created. The optimal discharge regimes were developed. These experiments were carried out for providing pre-ionization in the U-3M torsatron. At the same time the methods of the runaway electrons flow suppression by introducing of additional electrostatic potential on the confinement volume edge was suggested and checked.

12) Two polarization microwave interferometry for measurement of plasma density radial distribution in the U-2M torsatron. The prepared heterodyne interferometer has quadrature output signals which do not depend on the microwave signal transmitted through plasma varying in the limit 40 dB. The modeling of direct and inverse problems was provided for estimation of necessary accuracy in future experiments, and was

found that accuracy of phase measurements should be no worse than 4°. This is about factor two bigger than the real accuracy measured (≤ 2° within signal band 1 MHz), for the present moment, during conditioning discharges.
Future works: providing measurements at Uragan-2M during working pulses, modernization of interferometer for operation at two close frequencies, developments of multi-chord two polarization interferometry.

13) The work started on studying the plasma as a load of RF antenna. When plasma is produced and maintained by RF power, it is very important that RF generators are well matched with their RF antennas. This requires the measurements of RF antenna impedance along the whole RF discharge time. To find an impedance of RF antenna and a quality of antenna-generator matching, were measured (i) incident and reflected waves in a coaxial path with the use of a directional coupler fixed just after RF generator, and (ii) RF antenna current and voltage.
Because of nonlinear processes of RF field – plasma interaction, 4-channel ADC with a digitization rate 200 Mc/c and a buffer storage 16 Mc. Thus there appeared a possibility to poke the signals in a real view (Nyquist frequency 100 MHz and frequency of RF generator ≤ 10 MHz). First results have been obtained for conditioning RF discharges in Uragan-2M.

14) Development of surface relief on polycrystalline metals due to sputtering. The characteristics of surface microrelief that appears in sputtering experiments with polycrystalline metals of various grain sizes (from 20-70 nm up to 10-100 μm) have been studied. The characteristics of surface relief were obtained for specimens of crystallized amorphous alloys with grain sizes varying from 30–70 nm, Rh film on Cu substrate mirrors (crystallite size ≈100 nm), fine dispersed alloy Cu–Cr–Zr (200–300 nm), fine-grain molybdenum and tungsten (250–350 nm), ''ITER-grade'' tungsten (1–3 μm), and recrystallized tungsten (10-100 μm). Based on analyzing the results of experiments, a model is proposed for the development of roughness on polycrystalline metals. At the heart of the model is a well-known fact that sputtering yield is different for grains with differently oriented main crystallographic axes. The results of the computer modeling are in good agreement with the results of experiments, and do evidently show that the relief developing on the surface under sputtering has the scale length much exceeding the grain size.

Minutes of 42nd Stellarator-Heliotron Executive Committee Meeting

17th September, 2013

12:10 – 14:30

Centro Culturale S. Gaetano

(Venue of Joint 19th International Stellarator-Heliotron Workshop/16th IEA-RFP workshop)

Padova, Italy

<u>Attendees</u>

Australia	B.Blackwell
	J.Harris
EU	Per Helander (substitute for R.Wolf /T.Klinger)
	T. Sunn Pedersen (substitute for R.Wolf/T.Klinger)
	C.Hidalgo
Japan	H.Yamada
	T.Mutoh (substitute for A.Komori)
	M.Yokoyama (secretary)
Ukraine	S.Moiseenko (substitute for I.E.Garkusha and V.S.Voitsenya)
USA	M.C.Zarnstorff (vice chairperson)
	D.T.Anderson

<u>Observer</u>

USA	S.Prager

<u>Agenda</u>

1) Approval of agenda
2) Approval of minutes of 41st S-H ExCo meeting
3) Confirmation of membership of S-H ExCo
4) 20th International Stellarator-Heliotron Workshop
5) Status of domestic activities and international collaborations
6) Development of Stellarator-Heliotron working groups
7) Miscellaneous and final remarks

(participants' titles are omitted in the minutes)

Meeting was opened by Yamada. He passed the best regard from Komori who cannot attend the meeting with urgently-emerging tasks. The proposal, Yamada to act as a chairperson instead of him, was unanimously agreed.

1. Approval of Agenda

One agenda, discussion on SSOCG, under IEA IA, was proposed by Yamada to be added before agenda 5). SSOCG is organized with traversing all IAs. Mutoh is co-chairperson of this activity. The proposed agenda was approved with this addition.

2. Approval of minutes of the 41st S-H ExCo meeting

No corrections and comments were raised. The minutes were approved as they are.

3. Confirmation of membership of S-H ExCo

Yamada: No change of membership was confirmed. With regard to Russia, we discussed recent unavailability of Russian representatives in this meeting. Last ExCo, we asked M.Zarnstorff and M.Tendler to communicate Russian colleagues.

Zarnstorff: I sent an e-mail after the meeting, but no response. I will try again.

Yamada: I communicated with B.Kuteev to connect communication with GPI. I received an e-mail from the present deputy director of GPI, V.G.Mikhalevich. Fortunately, he said he would send a young staff to next Toki Conference (Nov. 2013). We will restart discussions with GPI.

Zarnstorff: Did you send an e-mail to Russian ExCo members?

Yokoyama: I sent an e-mail to L.M.Kovrizhnykh, and he replied that he would confirm the minutes of ExCo which I will send to him. In this way, he can still be an ExCo member.

Yamada: We will have a chance to talk with Russian people at least in next Toki Conference. Hopefully, we will have some Russian people attending next ExCo.

4. 20th International Stellarator-Heliotron Workshop 2015

Yamada: Before the decision of this joint workshop, we had already almost decided to have the next workshop in Greifswald.

Pedersen: We talked about this last time. This time, we will be ready to host it. Per Helander is going to act local organizer.

Helander: It should be in Greifswald?

Yamada: No, it's up to you. Before going to detail, can we confirm the next workshop in Germany?

All: Unanimously agree.

Helander: We just started to consider. Greifswald downtown might be convenient. How many people would attend?

Yamada: roughly 150.

Harris: We had it in the institute in 2003.

Helander: What would be the maximum conference fee?

Harris: roughly between 300~500 dollars.

Helander: Greifswald is not the most expensive part of the world. Not combining with RFP workshop? If we combine, more people will attend.

Harris: I actually would like to see RFP people.

Pedersen: I'm of the opposite opinion. It was good for us to combine this time, but I really want to have a standard part of program next time (S-H).

Zarnstorff: We combined with theory conference at previous one. Before that (Princeton) we were alone. I found both cases were interesting.

Prager: My guess is, for RFP people, helical state which is link to S-H is just a subset of their interests.

Hidalgo: Maybe compromise would be next workshop is S-H alone and, to keep a possibility to meet again.

Yamada: Next workshop is 2 years from now. Thus, it is not necessary to decide all now.

Moiseenko: You will have experiment at this timing (Oct. 2015).

Pedersen: Yes. It's a natural time for us to have the workshop in Greifswald. We will have the first plasma in the first half of 2015.
Yamada: When will we have to fix dates?
Helander: We will check the availability of the place I have in mind.
Yamada: Please check any conflicts of the schedule. According to the order, program committee chair would be from NIFS (All: Unanimously agreed). We will select a person to work with Per Helander. On the possibility of joint workshop, the counterpart is not necessarily RFP. It should be to maximize the outcome of the workshop. Do you have any ideas? This is a sort of brain-storming.

Possibilities of combined workshop with SSOCG (Steady State), ISFNT (International Symposium on Fusion Nuclear Technology), IAEA DEMO workshop, each topic (work plan) in European Roadmap. etc. are also discussed.

Yamada: I will talk about the possibility of joint workshop with J.Sarff and P.Martin.

Postscript:
The following message was sent to P.Martin, J.Sarff and S.Masamune on 18 Sep. 2013.
Dear John, Piero, Masamune-sensei,
Yesterday, we had the Stellarator-Heliotron ExCo and discussed the next WS. Our next WS will be in October, 2015 in Greifswald, Germany, when we will celebrate the first plasma of W7-X. We discussed the cooperation with RFP and some topics are complementary and stimulating. Therefore, although we do not need a full-joint WS like this time, some joint session (ex. stochastic magnetic field, 3-D MHD equilibrium etc) is certainly very attractive. I presume you have a thought similar to ours and we would appreciate if you could keep communication with us about how we will arrange the next WS. I have heard from Masamune-sensei that you will have the next WS in September 2015 in China. I would be happy if we could have complementary WS in Europe and Asia.
Best regards,
Hiroshi

The following discussion are made in RFP ExCo members, and in principle, it has been agreed to have some overlapping (eg., joint session) in the next individual workshop in 2015.
Piero and Sadao,
I discussed with Hiroshi our conversations about the Stellarator ExComm recommendation to have joint sessions at the next separate workshops in 2015 (Greifswald and Hefei). There seems to be agreement that this is a good strategy to maintain cross connection in our workshop series. For planning for the future, we thought that it would be good to include a stellarator person in our 2015 ExComm meeting in China, and likewise an RFP person in the 2015 Stellarator ExComm meeting in Greifswald. We could at these meetings discuss the possibility for a next joint workshop, for example possibly 2017.
Cheers,
John

5.1 Discussion on SSOCG

Yamada: Prof.Mutoh is now responsible for this activity. Please launch the discussion.
Mutoh: Steady state operation coordinated group is formally started under the umbrella of IEA FPCC. Co-chairs are myself and G.Sips. This activity was formed to strengthen coordinated program on SSO issues. The first meeting was held in this May at Aix-en- Province. At that time, we discussed activity and topics to form work packages, concentrating on overlapping subjects of physics and engineering issues. 7 subjects are listed, SSOCG1 to 7, covering almost all present and near-future devices. I would like to ask SH IA to make some documents on SS roadmap. Hopefully, we would like to make a report at the next FPCC in January 2014. Not so

large material is required, and the outline is enough. Next SSOCG will be held in October, 2013 in Japan. Membership of SSOCG from SH community are Yamada, Ascasibar, Dinklage and Kubo. Members and experts are more than 30, mainly from tokamak area. We hope some materials (even outline) come from SH community in this November or December.

Harris: What's striking me is the absence of divertors in the list. We have LHD with actively cooled divertor, and at W7-X, possibly they will run in actively-cooled condition. They will come before those in tokamaks.

Zarnstorff: EAST may come as well.

Mutoh: Any kinds of information on SSO are welcome to define clear next-step subjects.

Pedersen: Who would be the contact person for W7-X participation?

Yamada: How did you define the contact persons as listed?

Mutoh: They attended the first meeting.

Yamada: Do you have any specific reasons that divertors and plasma exhausts issues are not listed here?

Mutoh: These are items for just a first 1.5-year.

Yamada: Then, we should suggest divertor issues.

Zarnstorff: Power handling, PFC and etc as well. Some issues are headed to reactor and DEMO, and the others are more on near-term ones.

Hidalgo: The listed topics are quite broad. How about taking one of these lists as a top priority? Such as power exhaust and impurity transport.

Yamada: In a short time scale, let me propose to make some drafts by the end of this year, based on communication with Mutoh and Pedersen. Then, we will discuss based on a draft.

Zarnstorff: Diagnostics for SSO would be easily common topic.

Pedersen: I would receive formal contacts from Mutoh.

Mutoh: I will do.

5.2 Status of domestic activities and international collaborations

Australia

Blackwell: We now have continued operational funding. All facilities in Australia were threatened to be without funding for 18 months. At the last minute, the Government allocated an additional 180 MA$ in the budget. We only lost 2 people, approximately what was expected. We do not know what the new Government's attitude will be - it is a worrying sign that they have not yet appointed a Science Minister. Connection between fusion activities in Australia, essentially ANU and ANSTO (Australian Nuclear Science and Technology Organisation) for materials, began with memorandum between ANSTO and ANU. The Australian fusion community has agreed that ANSTO will lead any negotiations with ITER for future, some sort of involvement or connection to ITER. The CEO of ANSTO visited Cadarache early this year for discussions and is quite enthusiastic about fusion. We have operating funds until June 2015. We have to see what the new government, elected two weeks ago, thinks about the needs of national facilities.

Germany

Pedersen: We have been experiencing delays on assembly of vacuum vessel components, as I mentioned in my talk. Limiter configurations (OP1.1) will work for us. We are slowly changing into scientific phase; divisions will change (exception: theory division is already formed). Basically these changes are starting, at January 2014, some (whose contracts ending at the end of this year) will come into new scientific division with permanent contracts. Diagnostics are not completed yet, and thus diagnostic subdivision will remain, say for another 1-1.5 year. This transition will not be completed roughly until the first plasma. Generally, with this new plan, we will have something like 15 diagnostics ready for OP1.1, and implementing others for OP1.2. We are re-doing time plan for data acquisition and control systems, which have also seen delays. We will have the central operation system on time. Diagnostics will receive minimal support from the central data acquisition and control system, trigger-pulse, local data acquisition and data transfer. As for international collaborations highlights, a student staying at LHD has been working on helium beam diagnostics of edge plasma, previously there was a student on infrared spectroscopic measurement of plasma facing components in LHD. Making more formal framework to exchanges (students) has been discussed with Okamura. For US, active collaborations with national labs have been going on: trim coils, infrared cameras etc.. We are trying to reach out to universities in US as well, releasing letter of intent, as a formal way to getting information about potential collaborations. We have been informed that DoE has chosen Princeton as the coordinating US facilities for US collaborations. H.Neilson is the person of contact.

Anderson: If Wisconsin is interested in doing anything, should we go through Princeton?

Pedersen: You do not need to go through Princeton. Please talk to us to get a letter of intent. At some point of maturity, you talk to Princeton and say this is what we plan.

Other small-scale collaborations (also in theory side) are also mentioned.

Spain

Hidalgo: Spanish programs looking to the near-term future are crucial, such as commitment on diagnostics development (such as reflectometer) in W7-X. ITER is a pillar for everybody, also for Spanish program. We are committing in the area of diagnostics development including reflectometer, diagnostics for power exhaust. We need to put resources on such issues. ITER must be successful. We keep TJ-II running focusing on issues like impurity transport. We should keep TJ-II running.

Pedersen: Is the Spanish government supportive?

Hidalgo: Yes, there is a strong support from the Spanish government. But we are in a difficult time, economic crisis is affecting. Most crucial is a human factor. This is our concern.

Zarnstorff: How is it coming into play?

Hidalgo: The number of new positions is frozen. Our great concern is to keep next-generation scientists. We keep trying to create new positions for bright young scientists.

Helander: There are a number of young Spanish scientists in IPP.

Hidalgo: We should pay attention as a community. We are looking for the time scale, not 1 year, 2 years, but 10-years. In 10-years' timescale, we should have very successful operations of new facilities, ITER, JT-60SA and so on. We should pay attention to human factors as a strategic issue. As for international collaborations in CIEMAT, we are happy that Japanese colleagues are visiting TJ-II on specific targeted like fast particle control (Alfven mode controlled by heating, although underlined physics still understood). TJ-II delegates will join the coming LHD campaign in specific areas. Long standing collaboration is crucial, so that CIEMAT will strengthen our national, European, and international links. We have to pay attention to the social impact. We have to be careful for our activity, basic research but also for fully-oriented towards energy, to be a success. We have to make an effort to keep our commitment, for 10-years' time scale.

Ukraine

Moiseenko: We have two machines, Uragan 2-M/3-M. At Uragan-3M, we have increased RF power to 400 kW, and a corresponding increase of electron temperature occurred. Based on measured radial profiles of line emission, we have separate core (good confinement) and edge region (bad confinement), we probably should return measurement of magnetic surfaces. We will perform experiment in Uragan 2M, we plan to have RF experiments, wall conditioning, October to December. Then, we pursue hybrid concepts, we switch-off one coil to embed local open trap to try to see whether there is a confinement. Our calculation tells that there exists magnetic configuration; we have embedded mirror-ratio of 1.5. As for international collaboration, we have steady collaborations with CIEMAT (diagnostics), Uppsala University (hybrid concept).

USA

Anderson: I say a few words on HSX. HSX is continuing operation, we have funding through Feb.1, 2015. We have been given no indication funding beyond that. We have been looking at several issues like equilibrium reconstruction. E.Chlechowitz from Greifswald, put a new set of diagnostics, hopefully we will get some new results on equilibrium reconstruction. Heat pulse propagation study has been also done, comparing with results from gyrokinetic calculations. We see that temperature gradient scale length is getting relatively stiff. As for edge region, a postdoc from MIT, he has employed EMC3/EIRENE code to try to see how we can measure the edge of HSX to compare with code predictions. As Wilcox will talk this afternoon, in quasi-helical symmetric situation neoclassical ambipolarity does not determine radial electric field, where Reynolds stress plays important role. Funding situation is unclear.

Zarnstorff: In the US, there have been uncertainties for everyone's funding, because of uncertainties how much US pays to ITER. Also due to that fact that DoE is not succeeding to growing US fusion budget to cover ITER construction cost, in part taking out of US domestic programs. There have been proposals to increase overall package by some amount in coming years, but still not enough to cover total increase of cost needed for ITER. Peculiar behavior is HSX has been asked to re-compete again in the next year, although they did it last year (potentially). Some of them supposed to make progress and have more clarity in next couple of months. HSX is doing OK. Our collaborations on LHD and W7-X are doing OK, resonating overall fusion energy science program in the US to be facilitated with long-pulse superconducting devices. Stellarator-Heliotron collaborations have been strengthened over the last couple of years. It is very encouraging, and we are hopeful. We continue to try to look a possibility that, NCSX, renamed QUASAR, to be realized as a new medium-scale experiment. Last year, DoE, as a whole, refreshed planning on major facilities in next 10-20 years. They went to all of different branches of physical sciences they support, each of them advisory committee is set up to give them advice and write a report on major steps for coming 10-20 years. Fusion advisory committee, they listed and endorsed a high-priority a medium-scale stellarator experiment, which is very good. DoE put together overall reports. We know discussions are going on, but we do not know beyond that.

Administrative and evaluation process of strategic plans in US was explained by Zarnstorff and Prager according to Pedersen's question.

Japan

Yamada: Let me thank steady participation to LHD experiment. For example, latest collaborations with N.A.Pablant and S.Hudson from PPPL are very productive. Please take a look at a handout after the meeting. We are very pleased to report that we finally concluded the agreement about deuterium experiment with local governments (Toki, Tajimi and Mizunami cities and Gif prefecture) at the end of this March. We just started preparations, licensing process etc,. We will start new experimental phase of LHD experiment. We submitted the proposal to the MEXT, and it was assesed in the Science and Technology Council in the MEXT. Fortunately, our proposal was approved by the ministry. The report of approval was completed two weeks ago. In principle, the new stage of LHD experiment was approved, and therefore, LHD project is secured for another 10 years. Upon this approval, we requested the supplemental budget to the ministry. At this moment, the operational budget for LHD is 44M$ (1$=100JPY, for simplicity) a year (which does not include any salary). For the next year, we request supplemental budget for preparation, and another capital cost for tritium removal system. We collect all evacuated gas, oxidize and convert it into water, including tritium. We promised local residents and local governments to collect tritium as much as possible.

Zarnstorff: Have you already measured tritium level in neighboring water environment?

Yamada: Yes, we have measured it for twenty years continuously. We have a data. It (collecting tritium) is a scientific and engineering challenge to control small amount of tritium. Therefore, it is worth from the science and technology as well. Our new proposal has been approved in MEXT level, and sent to ministry of finance. We hope to get supplemental budget for preparation for the deuterium experiment in the next fiscal year. We would like to start the deuterium experiment by the end of FY 2015 (early 2016). Beyond the S-H study, MEXT has recently requested fusion community a unique voice for plans to establish engineering basis for DEMO and the definition of DEMO. MEXT requested JAEA and NIFS to setup a unique task force team to discuss about them. In the present definition, the only one document was published from Atomic Energy Commission in Japan (8 years ago). In that document, the first DEMO would be tokamak. I am appointed as the task force leader. We will make an interim report in January 2014, and the final report will be till January 2015. The team enthusiastically hears the voices from the community.

6. Development of Stellarator-Heliotron working groups

Yokoyama: CWGM11 was held in CIEMAT in March 2013. Hidalgo made an opening remarks how CWGM has been effective. Sessions listed in the handout were formed. Impurity issues were frequently mentioned, and we should formulate impurity-related session. There was a breif summary issued in Stellarator News (June 2013). CWGM 11 was full of presentations and then we could not have strategic discussions such as on joint experiment/papers. For future CWGMs, we should focus more on strategic discussion. Prioritization of topic and the identification of CWGM officer in each institution for more open and continuous discussions have been discussed. Please nominate a CWGM officer from your institute, if you find it to be effective. Lastly CWGM12 has been planned to be held after the close of this workshop. But session coordination is still under discussion. I will make an announcement tomorrow or the day after tomorrow. If you have a time, please join.

7. Miscellaneous and final remarks

- 2013 Annual Report: deadline should be the end of this year. Yokoyama will send around the e-mail asking contributions from each party.
- Next ExCo will be held in St. Petersburg during 25th IAEA Fusion Energy Conference, 2014.
- Closing remarks by Yamada.