USBPO U.S. BURNING PLASMA ORGANIZATION

eNews

December 23, 2010 (Issue 50)

CONTENTS

Dear Burning Plasma Aficionados:

This newsletter provides a short update on U.S. Burning Plasma Organization activities. E-News is also available online. Comments on articles in the newsletter may be sent to the Editor (Tom Rognlien) or Assistant Editor (Rita Wilkinson).

Thank you for your interest in Burning Plasma research in the U.S.!

Director's Corner by Jim Van Dam

ITPA Combined Meeting

In the past, the annual meetings for the Coordinating Committee of the International Tokamak Physics Activity (ITPA), IEA/ITPA Joint Experiments Planning, and the Executive Committee of the IEA Large Tokamak Agreement had been held in June, December, and May, respectively. Since the participants at these three meetings overlapped considerably, it was decided in July of this year to combine these three meetings and thereby reduce travel.

The first of these back-to-back meetings was held December 13-16 in Cadarache. The first day was devoted to reports from ITER Organization scientists about a number of technical issues for ITER, including ELM suppression, heat loads on plasma-facing components, heating and current drive, disruption avoidance/mitigation, and divertor plasma detachment. The usual reports from the ITPA Topical Group leaders were omitted, since the previous ITPA Coordinating Committee meeting had been held only six months earlier, in June. However, the Transport Topical Group and the Divertor-Scrape Off Layer Topical Group did report about the status of the coordination of modeling activities in support of joint experiments. The Integrated Operating Scenarios Topical Group has plans for similar coordination. The new ITPA web site,

Participants at the combined December 2010 meeting in Cadarache (photo courtesy of ITER)

hosted by the ITER Organization, was described. The Coordinating Committee also discussed the process to select new leaders and deputy leaders for the seven ITPA Topical Groups for three-year terms starting in December 2011.

Ron Stambaugh (left), outgoing Chair of the ITPA Coordinating Committee, being congratulated by David Campbell (right) of the ITER Organization (photo courtesy of ITER).

An important item of business on the first day of this combined meeting was selection of Yutaka Kamada from Japan to replace Ron Stambaugh as the Chair of the ITPA Coordinating Committee. Ron Stambaugh, Vice-President for the Magnetic Fusion Energy Program at General Atomics, has very ably served as the Chair since 2003. His seven-year term of service exceeded the normal three years specified in the ITPA Charter. One reason for his extended service was that this period coincided with significant changes in the relationships of the ITPA, the International Atomic Energy Agency, and the ITER Organization. Another reason, of course, is his very high level of competence. We sincerely thank Ron for his dedicated service through the ITPA to the world's fusion research community.

Yutaka Kamada, new Chair of the ITPA Coordinating Committee (photo courtesy of JAEA).

The new Chair of the ITPA is Yutaka Kamada of Japan Atomic Energy Agency. Currently he is the Japanese project manager for the JT-60SA Project. He has served as leader of the ITPA Pedestal and Edge Physics Topical Group and as a member of the ITPA Coordinating Committee. We welcome Kamada-san's direction.

The second day of the meeting was used for planning joint experiments. The seven ITPA Topical Groups presented reports about the status of their joint experiments and proposals for the coming year. The ITPA program of joint experiments is proceeding well and also bringing in new experimental facilities, such as KSTAR and EAST with their long-pulse capabilities, into these collaborative activities.

The last day and a half of the meeting constituted the first meeting of the Executive Committee for the IEA Co-operation on Tokamak Programs (CTP) Agreement. The merger of the former IEA Poloidal Divertor Agreement and Large Tokamak Agreement into the CTP Agreement was completed in July this year. Some remaining procedural issues resulting from the merger were addressed at this meeting. The plans of the various international fusion programs to study ITER high-priority R&D issues were described and discussed. There was a special presentation about the plans for a D-T campaign on JET, following the ITER-Like Wall experiments. There was also a discussion of the status of ongoing exchanges.

Because the joint arrangement of the three meetings worked well in its first trial, it was decided to continue to use this approach in future years.

ITER Council Meeting

The 7th Meeting of the ITER Council, led by its Chair, Evgeny Velikhov, was held in Cadarache on November 17 and 18. ITER Director-General Osamu Motojima reported about the status of the ITER Project, which had entered the Construction Phase immediately after the Baseline was approved at the Extraordinary ITER Council Meeting in July. Also, the Director-General described a new strategy for cost savings and cost containment. The Council encouraged efforts by the ITER Organization and the Domestic Agencies of the seven ITER Members to improve coordination and endorsed the proposed strategies for cost containment actions. Also, the Council adopted the budget for 2011; re-elected the chairs and vice-chairs of the ITER Council, Management Advisory Committee (MAC), Science and Technology Advisory Committee (STAC), and Test Blanket Module Program Committee; and decided on the new charges to be addressed by STAC and MAC. According to ScienceInsider magazine, the Director General also stated that he had deter-mined to include in-vessel ELM control coils in the design of ITER, even though they are not yet approved in the Baseline.

Participants at the 7th Meeting of the ITER Council (photo courtesy of ITER)

Director-General Motojima (left) and Igor Borovkov, Head of the ITER Council Russian Delegation (right), unveiling the foundation stone for the Headquarters Building; in the background, left to right, are Robert-Jan Smits, Head of the European Delegation, William Brinkman from the U.S. Department of Energy, and Council Chair Evgeny Velikhov. (photo courtesy of ITER)

In connection with the Council meeting, the ITER Organization celebrat-ed the official start of construction for the Head-quarters Office by unveiling the foundation stone. The

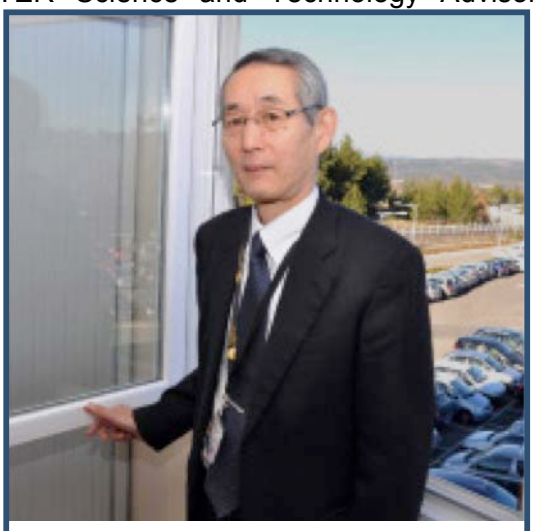
headquarters will consist of three buildings, one to receive the public, another with offices for 460 people and an amphitheater seating 500, and a third building to connect to the research facilities. It will take two years to construct these buildings. The contracting authority is Agence ITER France.

The press release from the meeting is posted on the ITER web site. The next ITER Council meeting will be June 15-16, 2011, in Japan.

New ITER Appointments

At its November meeting, the ITER Council appointed Remmelt Haange as Deputy Director-General and Head of the ITER Project Department. Dr. Haange is a very experienced fusion engineer. A native of the Netherlands, he obtained his nuclear engineering degrees at the German Technical University in Aachen. He then worked on the Dragon nuclear reactor project in the UK and subsequently moved to work at JET for 15 years. In 1993 he moved to work at the ITER Naka Joint Worksite in Japan, becoming Head of Site in 2003. He was called back to Germany in 2005 to lead the technical development of the Wendelstein 7X project. He has been a member of the European delegation to the ITER Science and Technology Advisory Committee meetings. According to the *ITER Newsline*, Dr. Haange will begin his duties at ITER on January 17, 2011.

Remmelt Haang, new Head of the ITER Project Department (photo courtesy of ITER)



Mitsuru Kondoh, new head of the Central Integration and Engineering Office for ITER (photo courtesy of ITER)

In a related development, Mitsuru Kondoh was appointed Head of the Central Integration and Engineering Office (CIE) at ITER in early December. The CIE Office manages all technical integration and project-wide engineering issues. While working at Toshiba, he was involved in the INTOR Project, the ITER Conceptual Design Activity and Engineering Design Activity phases, the construction of the Large Helical Device (LHD), and the upgrading of JT-60U into JT-60SA. In the mid-1990s, he worked under Remmelt Haange at the ITER Joint Work Site in Naka, Japan. Now they are re-united at Cadarache. In its latest issue, the *ITER Newsline* has an article about him.

Other ITER News

The complicated politics surrounding European funding for the ITER Project is the subject of a story in *World Nuclear News*. A similar article, more optimistic, can be found in Science magazine.

Fusion Power Associates Annual Meeting

The 31st Annual Meeting of the Fusion Power Associates, attended by U.S. and international senior fusion program leaders and U.S. policymakers, was held December 1-2 in Washington, D.C. The talks this year especially focused on the status of fusion research in light of the ignition experiments on the U.S. National Ignition Facility and the construction of the ITER

facility. Specifically ITER-related talks were those given by David Campbell (ITER Organization) on "Status of ITER," Ned Sauthoff (U.S. ITER Project Office) on "Status of U.S. Contributions to ITER," and yours truly on "The U.S. Burning Plasma Physics Program." On the second day, William Brinkman, Director of the Office of Science, talked about "Fusion in the DOE Office of Science," and Ed Synakowski, head of the Office of Fusion Energy Sciences, talked about "Office of Fusion Energy Sciences Strategy." Also there was a series of talks about the mission and need for a Fusion Nuclear Science Facility. All of the presentations are posted on the FPA web site (click on Annual Meetings). My talk is also posted on the USBPO web site. At the beginning of the meeting, Fusion Power Associates president Steve Dean presented Science Awards to Miklos Porkolab and Dmitri Ryutov, Leadership Awards to Riccardo Betti, and Martin Peng, the David Rose Engineering Award to Pravesh Patel, and Special Awards to Christopher Keane and John Willis. Congratulations to all of them.

Fusion Energy Coffee

How did we ever miss this earth-shaking news item? In the spirit of better late than never, here it is. In February 2007, SlashFood reported that 7-Eleven stores had released a new "Fusion Energy" coffee with natural herb extracts (ginseng, guarana, and yerba mate) to help kick-start your day. This distinctive coffee would boost your energy and sharpen mental alertness. Just what we all need, but, unfortunately, it no longer seems to be available.

Holiday Greetings

This is the last issue of *eNews* for the calendar year 2010. We wish you Happy Holidays, lots of energy and mental alertness, and all the best for the New Year.

USBPO Topical Group Highlights

(Editors note: The BPO Plasma-Wave Interactions Topical Group works to facilitate U.S. efforts to understand radio frequency plasma heating and current drive in existing and future magnetic fusion devices via experiments and simulations (leaders are Steve Wukitch and Gary Taylor). This month's Research Highlight by David Green, et al., summarizes an effort to simulate wave propagation from the antenna to the core plasma including wave propagation in the scrape off layer. The inclusion of the SOL illustrates a possible explanation for the observed dependence of fast wave heating on antenna phasing in NSTX.)

Simulation of Fast-Wave Coupling from the Plasma Edge to the Core

David L. Green, E. Fredrick Jaeger, Lee A. Berry, Guangye Chen, Dave Pugmire, Philip M. Ryan (all of Oak Ridge National Laboratory), Joel Hosea (Princeton Plasma Physics Laboratory), and the RF-SciDAC Team

Ion cyclotron range of frequency (ICRF) heating has been experimentally demonstrated to heat efficiently with an expected 20 MW to be employed on ITER [1]. Although ICRF is primarily planned for plasma heating in ITER, it can also be used to drive current which provides a means for adjusting the poloidal magnetic field. Recent work by the SciDAC Center for Simulation of Wave Plasma Interactions (CSWPI) has produced a linear 3-D electromagnetic field solver capable of realistic tokamak geometries for ICRF heating and current drive in plasmas relevant to ITER. The

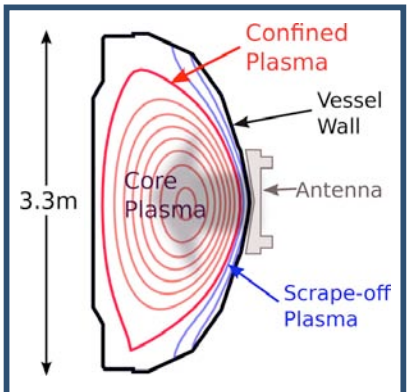


Fig. 1 Schematic of the 2D NSTX poloidal cross-section used in the simulations.

simulation code is an extension of the All Orders Spectral Algorithm (AORSA) [2] and includes both the core and the so-called scrape off layer (SOL) outside the last closed magnetic flux surface (LCFS). A typical fast-wave geometry, from the National Spherical Tokamak Experiment (NSTX), is shown schematically in Fig. 1 where the antenna is located in the scrape off layer (SOL) on the low magnetic-field side. The fast-wave must be coupled across the SOL to the core plasma. Although a realistic vacuum vessel wall can be included, the antenna is approximated by a current sheet with arbitrary distribution of antenna current in the poloidal direction. The 3-D wave fields are reconstructed using the toroidal mode spectrum corresponding to a specific RF phase shift between adjacent toroidally separated antenna straps in the 12-strap NSTX antenna. This extension to AORSA allows a 3-D reconstruction of

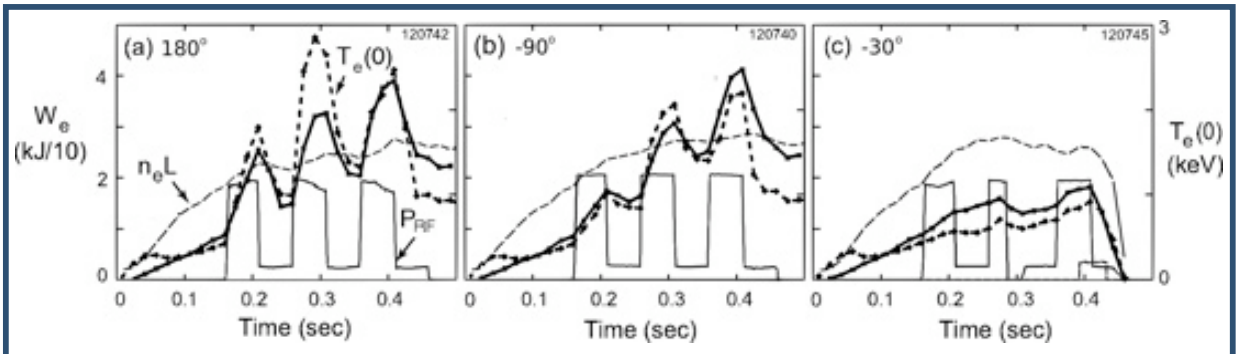


Fig. 2. Time evolution of the central electron temperature (thick dotted) and stored electron energy (thick solid) during helium NSTX discharges heated by amplitude modulated 30 MHz RF power (thin solid) launched with dominant k_φ equal to (a) 14 m^{-1}, (b) -8 m^{-1}, and (c) -3 m^{-1}. These launched k_φ values correspond to antenna strap-to-strap phase shifts (antenna phasings) of 180, -90 and -30 degrees, respectively. For these discharges, the axial toroidal magnetic field strength was 0.55 T, and the plasma current was 0.72 MA. From Ref. [5].

the steady-state wave electric field in both the core and scrape-off plasma regions. These wave fields can be readily visualized in 3-D. This capability can offer insight into underlying physics issues related to wave propagation and absorption.

We have compared the simulation with an ICRF experiment where the SOL is thought to play a significant role in the wave propagation and absorption. On NSTX [3], the ICRF heating efficiency has been observed to degrade with decreasing toroidal wavenumber (k_φ), as shown in Fig. 2 [5]. The dependence of heating efficiency on the launched k_φ has been interpreted [4,5] in terms of the location where the fast-wave transitions to a propagating wave, i.e., the onset location for fast-wave propagation (see Fig. 3). For scenarios with improved heating efficiency, this location is inside the well-confined core plasma (high temperature and pressure) defined by closed magnetic flux surfaces (see Fig. 1). Poor heating scenarios have the onset of propagation in the poorly confined SOL plasma that exists

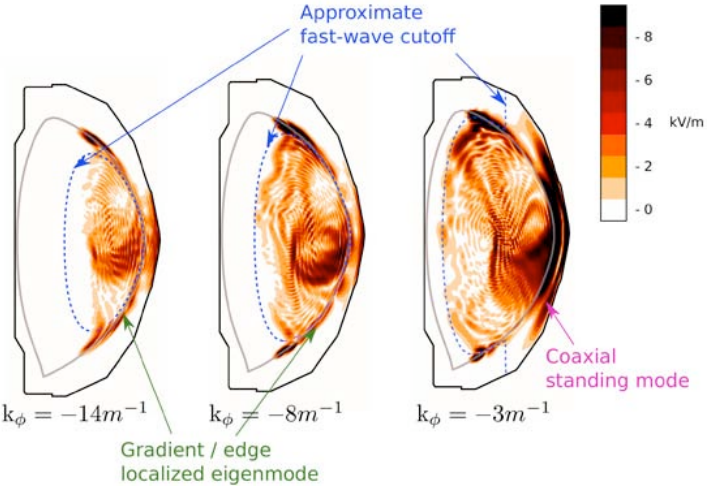


Fig. 3. 2D electric wave field magnitude calculated by AORSA for the toroidal wave numbers corresponding to the panels in Fig. 2.

near the wall on open magnetic field lines outside the LCFS and encompasses the antenna. Waves with a small k_φ can propagate in the SOL and damp via sheath effects or on collisions in the poorly confined plasma.

The electric wave fields for a Maxwellian helium plasma corresponding to the three experimental NSTX discharges in Fig. 2 are calculated using AORSA. Figure 3 shows results of 2-D calculations using a single toroidal mode corresponding to the dominant launched mode for each panel in Fig. 2. The fast-wave propagates inside the dashed blue surface, and as k_φ is decreased, this surface expands significantly such that it is outside the LCFS for the lowest k_φ. In Fig. 4, the full 3-D reconstructed wave electric fields are shown with the full toroidal mode antenna spectrum included in the simulation. From Fig. 3 and 4, large amplitude (kV/m) standing coaxial modes are seen to form in the SOL between the density gradient at the edge of the confined plasma and the vessel wall for the lowest k_φ (-30 degree phasing). Assuming the large edge wave fields are damped by collisions, the dissipated power in the scrape-off plasma could be significant and would significantly decrease the power absorbed in the core plasma. These modes are absent in the high k_φ (180 degree) case and where the heating efficiency is highest. The part of the fast-wave that couples to the core is seen to propagate farther into the plasma for increasing k_φ (see Fig. 3). Also, large amplitude edge-localized, field-aligned, traveling eigenmodes are excited just inside the density gradient of the core plasma. The simulation results qualitatively agree with the experiment and support the hypothesis that

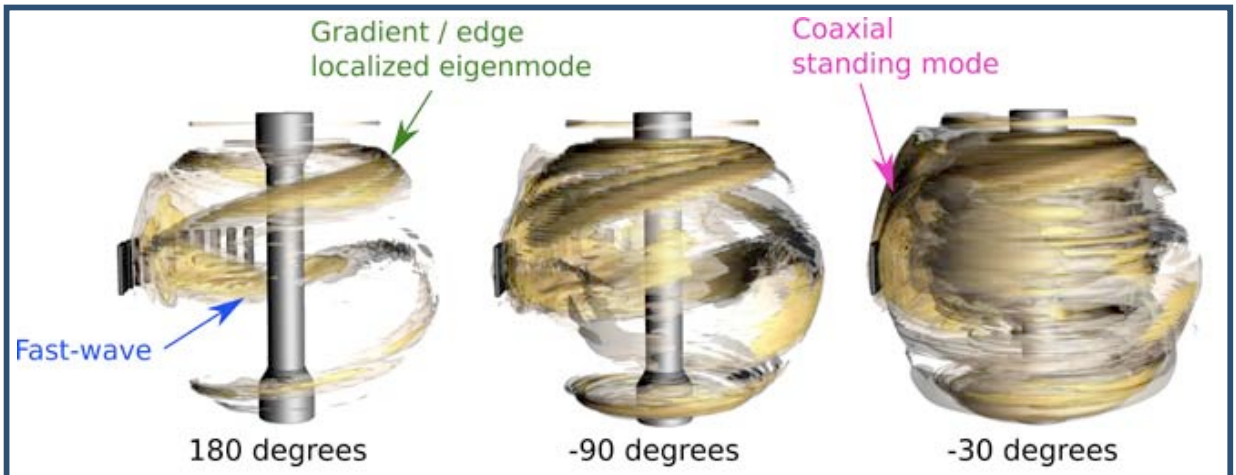


Fig. 4. 3D electric wave field magnitude for three antenna phasings corresponding to those in Fig. 2. Two contour surfaces are shown, yellow is 2.5 kV/m, gray is 1.5 kV/m. From Ref. [7].

excitation of coaxial edge modes likely reduce ICRF heating efficiency. This analysis is limited to qualitative comparison with experiment due to (i) algorithmic and computing power limitations that prevent resolution of the fine scale antenna and Faraday shield structures, and (ii) lack of available experimental data to accurately describe the 2-D density and temperature profiles. Future efforts will focus on overcoming these limitations to allow quantitative comparison of AORSA edge field predictions with experimental observations.

References

[1] N. Holtkamp, *et al.*, Fusion Eng. and Design **82**, 427 (2007), DOI: 10.1016/j.fusengdes.2007.03.029

[2] E.F. Jaeger, *et al.*, Phys. Rev. Lett. **90**, 195001 (2003), DOI: 10.1103/PhysRevLett.90.195001

[3] M. Ono, *et al.*, Nucl. Fusion **41**, 1435 (2001), DOI: 10.1088/0029-5515/41/10/311

[4] C.K. Phillips, *et al.*, Nucl. Fusion **49**, 075015 (2009), DOI: 10.1088/0029-5515/49/7/075015
[5] J. Hosea, *et al.*, Phys. Plasmas **15**, 056104 (2008), DOI: 10.1063/1.283705
[6] M. Ono, *et al.*, Phys. Plasmas **2**, 4075 (1995), DOI: 10.1063/1.871030
[7] D.L. Green, *et al.*, Submitted (December 2010) to the 6th Triennial Special Issue of the IEEE Transactions on Plasma Science, IMAGES IN PLASMA SCIENCE (August 2011)

ITPA Reports

Summary of the 5th Meeting of the ITPA Energetic Particles Topical Group, Seoul, Korea

Raffi Nazikian (Princeton Plasma Physics Laboratory)

The ITPA Topical Group on Energetic Particles (EP) held its 5th meeting at Seoul National University, Seoul, Korea, during October 18-20, 2010.

The EP group held a joint session with the ITPA MHD group on fast ion interactions with MHD modes and a joint session with the ITPA MHD and DIVSOL groups on disruptions. The joint session on plasma disruptions was largely focused on runaway electron control. An avalanche-type production of runaway electrons is expected to play the dominant role for ITER parameters. Massive gas injection is now considered as a primary mitigation technique. However, there is a strong need for more attractive alternatives. The specific ideas under consideration are (1) inversion of the loop voltage to slow down runaways, (2) injection of several dense gas puffs into the disrupting plasma to trigger MHD instabilities, and (3) the use of magnetic field perturbations to control transport of runaways.

The joint session with the MHD group discussed fast ion interactions with low frequency MHD activity. Results from the FIDA (Fast Ion D-alpha) diagnostic were presented from DIII-D indicating that more poloidally circulating (passing) beam ions than magnetically trapped beam ions are redistributed at the sawtooth crash. New core FIDA data on the ASDEX-Upgrade (AUG) tokamak indicate a drop in central fast ion density with the onset of Alfvén eigenmodes, similar to observations on the DIII-D tokamak. A highlight of the session was the presentation of Alfvén eigenmode temperature structure on DIII-D and AUG using electron-cyclotron emission (ECE) imaging. These results demonstrated the rapid progress made in the technology of ECE imaging and the important scientific data it reveals on the nonperturbative effect of the fast ions on the mode structure.

The group was informed of an effort to assess the capabilities of magnetic probes for Alfvén eigenmode detection in ITER. It has been noted that the probes are not likely to detect high toroidal mode number (n) internal perturbations up to n=40, because these perturbations decay rapidly toward the plasma edge. The envisioned large number of probes may therefore be excessive; however, they have the advantage of ensuring maximum redundancy.

A major focus of the meeting was the results of analysis concerning fast ion losses induced by 3D magnetic field perturbations. Results of an international collaboration assessing the DIII-D Test Blanket Module (TBM) mock-up experiments were presented (also see the March 2010 issue of eNews). Both guiding-center ion orbit (ASCOT, OFMC) and full orbit (SPIRAL) calculations of the losses to the wall from the TBM mock-up were in general agreement with thermocouple measurements obtained behind the protective carbon tiles. However the footprint of the beam loss on the TBM were quite different, particularly when using VMEC MHD equilibrium calculations. It is recommended that any future experiments should instrument the wall tiles to better resolve the power deposition profile, either with additional thermocouples or with infrared (IR) imaging. In an interesting related development, the measured Triton confinement in DIII-D was observed to decrease by 30% with the activation of

the resonant magnetic perturbation (RMP) coils used for ELM control. Analysis using SPIRAL reproduced this loss. The reason for the large loss of tritons is that the orbits of the confined tritons are so large that they necessarily intersect the edge where the perturbed magnetic fields are concentrated. Analysis of ITER RMP coils showed that up to 5-6% 1 MeV beam ion losses could be produced by the n=4 coil configuration, however, the level of power loss to the wall appears to be acceptable relative to the ITER design value.

Progress on joint modeling of Alfvén eigenmodes was reported. The linear benchmark of various codes has been a key activity of the ITPA EP group since its inception. Good agreement was reported for all codes on mode frequency and mode structure for JET equilibrium profiles. It was shown that continuum damping at the edge is highly sensitive to small variations in the plasma profiles so that very high accuracy in the measurements is required to ascertain the correct edge-damping rate. No significant discrepancy was found between the theoretical analysis of JET profile data and antenna excitation measurements of damping rates on JET.

Three new theoretical results were presented on the kinetic description of linear and nonlinear energetic-particle driven modes: (1) Recent realistic simulations of low-frequency modes with the LIGKA code have extended the mode description beyond the idealizations of the previous analytical theory, and they thereby explain the mode frequencies observed in AUG. (2) The destabilizing role of dynamical friction (drag) on resonant particles has now been demonstrated in the fully nonlinear regime of mode evolution when the phase-space holes and clumps give rise to spontaneous frequency sweeping. (3) The nonlinear frequency-sweeping model has been used to analyze the experimental data from MAST and JT60-U in order to find the instability drive and the effective collision frequency for resonant particles.

The group also discussed ongoing and future joint experiments and modeling efforts for fast ion losses due to 3D magnetic fields. Two major new ITPA research topics were discussed for 2011: (1) joint experiment and modelling for TBM mock-up coils on DIII-D and (2) studies of effects of ELMs and ELM mitigation coils on fast-ion losses and associated heat loads to plasma-facing components.

The next (spring) meeting of the Energetic Particles Topical Group will be in Frascati, Italy (April 11-13, 2011).

Summary of the 5th Meeting of the ITPA Transport and Confinement Topical Group, Seoul, Korea

Stan Kaye (Princeton Plasma Physics Laboratory)

The 5th meeting of the Transport and Confinement ITPA Topical Group was held at Seoul National University on Oct 18-20, 2010, Monday to Wednesday of the week following the IAEA FEC conference in Daejeon, Korea. Because of the proximity of the two meetings, the ITPA meeting was well attended with over 40 participants. The meeting covered several specific topics as well as having discussions of ITPA-specific database work, and the 2010 results and 2011 planning for the group's Joint Experiments (JEX) and Joint Activities (JAC) work. For the database work, progress has been made on the Momentum Transport database, and a series of Action Items were discussed, leading to a possible presentation/paper for next fall's H-mode workshop. The group also discussed the L-H Threshold database, and the consensus was to have each machine provide data for this database by the next ITPA meeting in Spring 2011.

Several sessions on 3D physics were held in order to identify the common physics between tokamaks and stellarators, with an aim toward developing joint experiments between the two classes of devices. The first session was on the effect of 3D magnetic fields (stellarators and tokamaks with applied edge perturbations) on mean plasma flows, zonal flows, geodesic acoustic modes (GAMs), etc. In particular, the roles of both neoclassical and turbulent transport in stellarators were found to be comparable to those in tokamaks in terms of driving and

damping the mean flows. The possible role that zonal flows may have as a trigger for the L-H transition was discussed, as was the role of fluctuating sheared flows. The theory of the 3D zonal flow physics, with the relation between zonal flows and drift wave turbulence as a framework for the predator-prey model connecting flow damping and turbulence, was discussed. This model seems to be supported by the observation of fluctuating flows in both stellarators and tokamaks.

The next session focused on 3D effects for the low-to-high confinement (L-H) transition. In retrospect, this session was very closely related to the 3D effects on flows session, and many of the same topics were covered. This latter session, however, was a joint session between the T&C and Pedestal Topical groups. In an overview of L-H transitions in stellarators, the similarity of the H-mode in the stellarator and tokamak was pointed out. For stellarators, the magnetic configuration has great leverage for accessing the L-H transition and, thus, high-confinement H-mode. Beneficial configuration effects include: windows in rotational transform of the magnetic field (iota-bar) for attaining the quiescent H-mode, the proximity of low-order rational magnetic surfaces to the plasma edge in TJ-II, the magnetic axis location in CHS and LHD, and the presence of an ergodic layer in LHD. It was pointed out that both the mean and fluctuating flows observed in the stellarators, as well as the 3D effects on L-H transition observed in a range of tokamaks (JET, JT-60U, NSTX, MAST, DIII-D), all indicate that applying the 3D fields results in higher power thresholds for the L-H transition. The theory behind the 3D effects was also discussed.

Finally, there was a presentation on impurity transport in stellarators, indicating that it is the neoclassical radial electric field (E_r) that dominates the particle pinch with impurity accumulation occurring for $E_r<0$. Methods for reducing this impurity accumulation were discussed, including creating a stochastic layer near the plasma edge, creating flat density profiles, enhancing the outward convection through the electron root $E_r>0$, and generating an ion internal transport barrier (ITB), which is observed to create an impurity hole in experiments.

Pedestal and particle transport issues were discussed in a joint session among T&C, Pedestal, Integrated Operating Scenarios (IOS), and DIVSOL Topical Groups. In particular, a comprehensive work scope for a proposed Particle Transport Working Group that would be crosscutting among the four groups was presented.

A session was conducted on transport model validation during plasma current ramp-up. Data for ITER-similar current ramp plasma discharges from C-Mod, DIII-D and JET have been committed to the profile database, and final data validation checks are being made. A presentation showed that scaling JET and C-Mod electron temperature (T_e) profile shapes with various confinement assumptions leads to a determination of the possible range of internal inductance (li) in ITER plasmas. This approach is made possible by the robustness of the profile shapes during the current ramp-up phase in these machines. Other modeling results were also presented using Coppi-Tang and Bohm-gyroBohm transport models.

ITBs were also discussed, first jointly with the IOS Topical Group. Critical issues for understanding the triggering and sustainment of ITBs were presented for both ion and electron ITBs. The talks clearly highlighted some of the key issues, and each one elicited a great deal of interest and discussion. Methods for achieving steady-state ITBs for ITER scenarios were discussed. Theory results showed that ITBs could exhibit back-transitions, hysteresis and the development of intrinsic rotation, as is observed in H-mode regimes.

The final day of the meeting was mostly devoted to presentations of JEX/JAC 2010 summaries and 2011 proposals, although a short session on the I-mode was also held.

The next meeting of the ITPA Transport and Confinement Topical Group will be held in San Diego on April 4 and 5, 2011, immediately preceding the U.S. TTF meeting.

Community Reports

Progress on Joint Facilities and Theory Research Target in 2011

Richard Hawryluk (Princeton Plasma Physics Laboratory)

For many years, the US fusion program has had a yearly joint facilities research target and a separate theory research target. This year DOE has combined the targets to focus on understanding the edge pedestal region of a tokamak discharge, to improve our ability to predict the width and height of the pedestal. In high-confinement (H-mode) discharges, the pedestal region has a large positive impact on confinement since the ion temperature profiles are relatively stiff, i.e., an increase in the pedestal temperature results in a substantial increase in temperature throughout the core region. Thus, the height of the pedestal bears directly on fusion performance in ITER. On the other hand, the width is important as well. The pressure and current profile gradients determine the onset of edge localized modes (ELMs) in the edge region. If the edge profiles were very narrow, such modes could limit the pedestal height and hence global energy confinement. Alternatively, if the edge profiles were very broad, that could result in either an ELM-free H-mode, with impurity and particle buildup, or a low-confinement L-mode. Thus, understanding what determines the height and width of the pedestal is important for predicting the performance of ELMing H-mode discharges in ITER, which is the baseline operational regime.

Of course, the phenomenology of the regimes is even more complicated than just described for other operating modes such as quiescent or QH-mode, improved or I-mode, Enhanced D-alpha or EDA H-mode, scenarios with ELMs suppressed by resonant magnetic perturbations (RMP), and small ELM regimes of various types; these were extensively discussed at recent IAEA and ITPA meetings in Korea. Furthermore, there is the related issue of damage to the divertor target plates by ELMs. While different operating regimes will be used to test different models and hypotheses, and provide ancillary information about divertor target heat loads from ELMs, the focus of the Research Target will be on understanding the pedestal structure in H-mode discharges.

The combined joint research targets are:

Experiment:

"Improve the understanding of the physics mechanisms responsible for the structure of the pedestal and compare with the predictive models described in the companion theory milestone. Perform experiments to test theoretical physics models in the pedestal region on multiple devices over a broad range of plasma parameters (e.g., collisionality, beta, and aspect ratio). Detailed measurements of the height and width of the pedestal will be performed augmented by measurements of the radial electric field. The evolution of these parameters during the discharge will be studied. Initial measurements of the turbulence in the pedestal region will also be performed to improve understanding of the relationship between edge turbulent transport and pedestal structure.

Theory:

"A focused analytic theory and computational effort, including large-scale simulations, will be used to identify and quantify relevant physics mechanisms controlling the structure of the pedestal. The performance of future burning plasmas is strongly correlated with the pressure at the top of the edge transport barrier (or pedestal height). Predicting the pedestal height has proved challenging due to a wide and overlapping range of relevant spatiotemporal scales, geometrical complexity, and a variety of potentially important physics mechanisms. Predictive models will be developed and key features of each model will be tested against observations, to

clarify the relative importance of various physics mechanisms, and to make progress in developing a validated physics model for the pedestal height."

In preparation for this effort, two workshops have been conducted this year. The DIII-D workshop was held at GA in February, and the C-Mod/NSTX workshop was held at PPPL in September. An outcome of these meetings is a table listing scientific topics, the experimental facilities capable of addressing each, the tentative priority of the topic, and which codes will be used to analyze and interpret the results. Of the 17 topics under discussion, some of those likely to receive substantial attention include:

- Evaluate height and width predictions of EPED/ELITE
- Search for kinetic ballooning modes (KBM)
- Evaluate paleoclassical predictions
- Role of ExB shear and turbulence fluctuations
- Role of neutral fueling
- Role of neoclassical vs anomalous transport
- Evaluate transport predictions in pedestal formation of different operating regimes (I-mode, EDA, ELMy H-mode, RMP, EPH, VH, QH)

Further review of the experimental topics will take place as part of the Research Opportunities Forum at DIII-D (Dec. 7-9, 2010 with ongoing topical discussions), the Ideas Forum at C-Mod (Jan. 10-12, 2011) and Research Forum at NSTX (Mar. 2011, exact date TBD). The C-Mod team has begun taking data to support this milestone and will continue with the current run campaign through March, while NSTX and DIII-D will resume operations around May. Thus, there is significant opportunity to define the experimental programs in this area on NSTX and DIII-D, as well as some capability to tune and refine plans on C-Mod. The involvement of the theory and computational community is critical for the success of this Joint Research Target. While many codes will be applied to this effort, additional comparison between simulations and experiments would be valuable and the group working on the pedestal target welcomes further community involvement. The experimental research teams have indicated that priority will be given to topics that can result in a conclusive comparison with theory or simulation codes. In addition, the experimental research teams will each make available data sets for use in theory or simulation activities.

A working group meets regularly to coordinate the activities in support of this Joint Research Target including, C.S. Chang, P. Diamond, R. Groebner, R. Hawryluk, J. Hughes, R. Maingi, P. Snyder and X. Xu. People interested in collaborating on the experiments or participating in the analysis of the experimental results should contact J. Hughes for C-Mod, R. Groebner for DIII-D and R. Maingi for NSTX.

Announcements

Submit BPO-related announcements for next month's eNews to Tom Rognlien.

Upcoming Burning Plasma Events

2011 Events

April 6-9, 2011
ITPA Transport & Confinement Topical Group Meeting (following US/EU TIF)
San Diego, CA USA

April 11-14, 2011 NEW **abstract deadline Dec. 23, 2010 email: sfp@fz-juelich.de**
Workshop on Stochasticity in Fusion Plasmas (SFP 2011)
Jülich, Germany

May 2-4, 2011 NEW
2011 International Sherwood Fusion Theory Conference
Austin, TX USA

May 9-13, 2011 NEW
13th International Workshop on Plasma-Facing Materials and Components for Fusion Applications (PFMC-13) and 1st International Conference on Fusion Energy Materials Science (FEMaS-1)
Rosenheim, Germany

May 15-19, 2011
15th International Conference on Emerging Nuclear Energy Systems (ICENES)
San Francisco, CA USA

June 1-3, 2011 NEW
19th Topical Conference on Radio Frequency Power in Plasmas (CKPhil and JR Wils PPPL)
Newport, RI USA

June 26-30, 2011
38th IEEE International Conference on Plasma Science (ICOPS) and the 24th Symposium on Fusion Engineering (SOFE)
Chicago, IL USA

Jun 27-Jul 1, 2011 NEW
38th European Physical Society Conference on Plasma Physics
Strasbourg, FR EPS

Sep 11-16, 2011 NEW
10th International Symposium on Fusion Nuclear Technology
Portland, Oregon USA

Sep 19-21, 2011 NEW
Plasma Edge Theory Meeting
South Lake Tahoe, CA USA

Oct 16-21, 2011
15th International Conference on Fusion Reactor Materials (ICFRM-15)
Charleston, SC USA

Nov 14-18, 2011 NEW
53rd APS Division of Plasma Physics Annual Meeting
Salt Lake City, Utah USA

Directories of Other Plasma Events

IEEE Directory of Plasma Conferences
Fusion Ignition Research Experiment (FIRE) Physics Meetings

Please contact the administrator with additions and corrections.