USBPO U.S. BURNING PLASMA ORGANIZATION

eNews

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Dear Burning Plasma Aficionados:

This newsletter provides a short update on U.S. Burning Plasma Organization activities. E-News is also available online at http://burningplasma.org/enews.html Please note that this issue is a combined May/June eNews, though generally there will be monthly editions. Comments on articles in the newsletter may be sent to the Editor (Tom Rognlien trognlien@llnl.gov) or Assistant Editor (Rita Wilkinson ritaw@mail.utexas.edu).

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

Director's Corner by Jim Van Dam

USBPO Comes of Age

This month, the US Burning Plasma Organization turns five years old—finally old enough to graduate from kindergarten. Our official "birthday" was May 2, 2005, the date on which the US Department of Energy appointed Prof. Ray Fonck as the founding director of the USBPO. This was the first formal recognition of the USBPO as a community-based organization to *"promote research on burning plasma science issues, provide an efficient and effective technical coordination among these programs, and work closely with the U.S. ITER Project Office in providing our best contributions to the ITER Physics basis"* (quoting from the announcement by Dr. Anne Davies, then-Associate Director for Fusion Energy Sciences).

Just to review some ancient history, let me note that the official establishment of the USBPO had been predated by the temporary existence of an 11-member US Burning Plasma Program Advisory Committee, which was active during 2003 and 2004. This PAC provided advice to the US ITER Project Office about bidding for selected ITER procurement packages. Also, the PAC sponsored an ITER Forum meeting (May 2003 in Maryland) to inform the US community members about ITER plans and engage them in ITER preparatory work. Importantly, this PAC examined the structure of other large-scale international science projects (e.g., the Large Hadron Collider and the ALMA and GEMINI telescopes) and eventually submitted a report to DOE with a proposal for how to structure a permanent national organization that would guide the US burning plasma effort. Stewart Prager, chair of the BP-PAC, described the activities of the PAC at the Fusion Energy Sciences Advisory Committee meeting in July 2003. The PAC's report was completed in October 2003 and subsequently submitted to DOE for consideration of its recommendations. At the annual OFES Budget Planning Meeting in March 2005, the BP-PAC chair gave a talk on "Goals and Guiding Principles of a US Burning Plasma Organization," after which the members of the BP-PAC participated in a panel discussion about the need for a "US Burning Plasma Organization."

Soon afterward, in May 2005, following the appointment of Ray Fonck as the first USBPO director charged to actually set up the new organization, things started moving quickly. Tony Taylor became the deputy director; the USBPO organized a community-wide Burning Plasma Workshop in December 2005 at Oak Ridge National Laboratory; the first issue of *eNews* was published in March 2006; the first Council meeting was held in April 2006; the first Leaders and Deputy Leaders of the Topical Groups were selected shortly thereafter—and the USBPO was off and running.

USBPO Council Election Results

In both the March and April issues of *eNews*, we reported that the USBPO Council would hold an election for new members. As a reminder, there are 12 Council members, and each year four members finish their terms of service and rotate off. This year, the retiring members are Amanda Hubbard, John Sarff, Tony Taylor, and Mike Zarnstorff. They have served the Council and, by extension, the US fusion program with distinction. We sincerely thank them for their extremely valuable contributions and their dedication.

Of the four new Council members each year, two are elected and two are appointed. The Council election was held recently. It's a pleasure to welcome Troy Carter (UCLA), Steve Knowlton (Auburn), and Cynthia Phillips (PPPL) as newly elected members of the Council, and Richard Buttery (GA) as a newly appointed member, with three-year terms. Congratulations to all of them.

I'd like to thank the members of the Nominating Committee—Steve Allen, Don Batchelor, Amanda Hubbard, John Sarff (chair), Tony Taylor, and Michael Zarnstorff—for their fine work in broadly soliciting nominations and then coming up with a slate of five well qualified candidates.

The election itself was carried out with a web-based system provided by the University of Wisconsin, under the competent oversight of Jim DeKock (USBPO Communication Coordinator) and Rita Wilkinson (USBPO Administrator). The poll opened April 19 and closed on May 4, during which period 158 regular members of the USBPO cast ballots, almost exactly the same number as last year. The results were unique in that, for the first time, there was a tie between two of the top three vote getters. This was resolved by the use of one of the appointee slots, so as to keep all three of these persons. The other appointee position was then filled, in accordance with the Bylaws, with an eye on broad community representation.

Leadership Changes for USBPO Council

This year we have the situation where the present Chair and Vice-Chair of the Council are retiring together. (The Council recent approved a modification to the Bylaws that will ensure a continuous succession of leadership.)

Amanda Hubbard and Mike Zarnstorff are the outgoing Chair and Vice-Chair. They have been absolutely outstanding in their service in these roles; words are inadequate to express our sincere appreciation to them.

Let me remind you that the Chair and Vice-Chair of the Council not only have the responsibility to organize and lead the Council meetings. They also participate in the biweekly teleconference meetings of the Executive Committee and are constantly involved in USBPO decisions via email. Hence, the high levels of involvement of the Chair and Vice-Chair represent a very large commitment of time and energy.

Both Amanda and Mike are charter participants of the USBPO Council. When the Council was originally established in March 2006, she was the first-ever Vice Chair and he was a member. In February 2007, she became the Chair and he became the Vice Chair. In those positions, they have served for three years. Their dedication and leadership skills have been highly valued.

I am very pleased to announce that Mike Mauel has agreed to serve as the new Chair, and Michael Bell has agreed to serve as the new Vice-Chair. Both of them are extremely competent and enthusiastic, and we look forward to working with them.

Amanda Hubbard
(retiring Council Chair)

Mike Zarnstorff
(retiring Council Vice-Chair)

Recent USBPO Council Meeting

The tradition of the Council has been to hold a "passing the torch" meeting in early summer at which the outgoing, continuing, and incoming members participate together. This meeting was recently held, on June 11. The new Chair, Mike Mauel, and the new Vice-Chair, Michael Bell led this meeting. The agenda had been prepared in consultation with the outgoing Chair and Vice-Chair, Amanda Hubbard and Mike Zarnstorff.

One of the early items of business on the agenda was an announcement by Erol Oktay (DOE) that the Office of Fusion Energy Sciences had re-appointed me as USBPO Director for another three-year period, along with Chuck Greenfield as Deputy Director and Nermin Uckan as Assistant Director for ITER Liaison. I am delighted that Chuck and Nermin will be continuing in their roles, in which they have been absolutely outstanding. Also, I am pleased that Jim DeKock will continue as Communications Coordinator and Rita Wilkinson as Administrator for the USBPO.

As mentioned earlier, the Council approved an amendment to the Bylaws to ensure a regular succession of leadership. As revised, the Bylaws now say: “The Chair and Vice-Chair each serve a two -year term, and their Council membership will be extended, if necessary, to the end of that term. To enable continuity of leadership, a serving Vice-Chair is eligible to become the new Council Chair, even if his or her term on Council would otherwise be ending.”

This amendment was inspired by the coincidence of the Chair and Vice-Chair retiring at the same time this year.

Another amendment to the Bylaw was also motivated by an unexpected event, namely, the tie vote in the recent Council election, mentioned earlier in this column. The amended Bylaws now say that the USBPO Director will cast a deciding vote in the event of a tie. The lesson here is that we live and learn—and amend the Bylaws accordingly.

The Council heard various reports about recent activities of the USBPO related to the Topical Groups, the ITPA, the US ITER Project Office, and the ITER Organization, including the following items:

- Recent ITER Physics Tasks, as well as the procedures for submitting work proposals
- STAC-8 meeting (see the next section of this column)
- 2010 ITER Summer School (a report on this will be reserved for the July issue of *eNews*)
- Alternate ELM control brainstorming session and the summary report subsequently presented at the ITPA Pedestal Topical Group workshop
- ITER workshop on TBM impact and the summary report by Erol Oktay
- ITER request for volunteers to help define the Plasma Control System (five persons from the US have responded)
- Recent USBPO talks and presentations
- USBPO activities planned for this year's APS-DPP Annual Meeting, including an ITER contributed oral session and a Town Meeting
- International collaborations (a full report will be published in a forthcoming issue of eNews)
- USBPO involvement in fusion nuclear science issues.

The Council also endorsed the recommendations for new leadership for the USBPO Topical Groups (see next section).

USBPO Topical Group Leadership Rotation

The terms for the USBPO Topical Group leadership positions have been staggered so that half (five) of the Leaders' terms will expire each year. This year, vacancies opened in the leadership of the following groups:

USBPO Topical Group	**Outgoing Leader**	**Current Deputy Leader**
MHD, Macroscopic Plasma Physics	Chris Hegna (UW)	Ted Strait (GA)
Confinement and Transport	Edward Doyle (UCLA)	John Rice (MIT)
Integrated Scenarios	Chuck Kessel (PPPL)	John Ferron (GA)
Modeling and Simulation	Don Batchelor (ORNL)	Dylan Brennan (U Tulsa)
Diagnostics	Steve Allen (LLNL)	Jim Terry (MIT)

I'd like to express sincere gratitude to the outgoing Topical Group leaders—Chris Hegna, Edward Doyle, Chuck Kessel, Don Batchelor, and Steve Allen. The Topical Groups are the "working core" of the USBPO, and they have provided very positive and beneficial representation for these various topical science areas. Two of them also serve as ITPA topical group members, and one serves as a member of an ITER expert working group. We have definitely appreciated their many contributions.

The members of these five Topical Groups were asked for nominations. Suggestions were also received from other scientists in the US community.

The proposal for new leadership that was submitted to and endorsed by the USBPO Council at its June 11 meeting had two parts:

1. That the current Deputy Leaders be promoted to become the new Leaders of these five Topical Groups.

2. That George McKee, David Brower, Amanda Hubbard, François Waelbroeck, and David Mikkelsen be appointed as the new Deputy Leaders for these five groups.

The chart below summarizes the new Topical Group leadership:

USBPO Topical Group	New Leader	New Deputy Leader
MHD, Macroscopic Plasma Physics	Ted Strait (GA)	François Waelbroeck (Texas)
Confinement and Transport	John Rice (MIT)	George McKee (Wisconsin)
Integrated Scenarios	John Ferron (GA)	Amanda Hubbard (MIT)
Modeling and Simulation	Dylan Brennan (Tulsa)	David Mikkelsen (PPPL)
Diagnostics	Jim Terry (MIT)	David Brower (UCLA)

We are grateful for the willingness of the former Deputy Leaders to now become the Leaders of these groups and for the interest expressed by those who now assume the responsibilities as new Deputy Leaders. Special kudos go to Amanda Hubbard, who, after finishing a very busy three-year term as Council Chair, is immediately willing to jump into the role of leading a Topical Group.

It's interesting to note that with the new Council members and the upcoming rotation of Topical Group leaders, almost all of the original people will have been replaced. This is a noteworthy aspect of the USBPO "coming of age": the organization outlasts individuals and continues to function smoothly.

STAC-8 Meeting

The ITER Council's Science and Technology Advisory Committee (STAC) held its eighth meeting May 10-12 in Cadarache, France. This was the first meeting led by the new STAC chair and vice-chair, Prof. Yuanxi Wan (ASIPP Hefei) and Prof. Minh Quang Tran (CRPP Lausanne), respectively. Incidentally, the May 14 issue of *ITER Newsline* has an interesting article about Prof. Wan (http://www.iter.org/newsline/Pages/131/1901.aspx).

The Council at its November 2009 meeting (IC-5) had formulated a set of charges for STAC-8 to help it take up the task of approving the ITER technical baseline at its upcoming IC-6 meeting. This initial set of charges consisted of five items:

- Review the plan of the ITER Organization (IO) for evolution from First Plasma to DT research, evaluating the compatibility and suitability of the ITER Research Plan with the proposed Overall Project Schedule, emphasizing achieving effective DT research operations as rapidly as possible.
- Review the current plans and issues with in-vessel coils, including the integrated design with in-vessel components and the vacuum vessel and any alternative strategy for vertical stability.
- Review the full operational space for the range of plasma scenarios.
- Review the current plan for ELM mitigation, addressing not only the R&D, design, risks and benefits of In-vessel ELM-mitigation Coils but also the world-wide R&D program aimed at developing alternative methods for mitigating ELMs.
- Review requirements for heat loads in the first-wall design, including balance between steady state heat loads and transients.

Subsequently, the Chair of the ITER Council requested the STAC to address a sixth charge:

- Assessment of the impact on the research plan from the first plasma to the effective D-T operation by the changes of the new assembly procedure proposed by IO in the "Improved Updated Schedule."

During the STAC-8 meeting, however, the ITER team reported that no new assembly procedure was being proposed, and therefore the STAC did not consider this last charge.

In addition, again at the request of the ITER Council (IC-5), the STAC undertook a re-examination of the option of retaining carbon divertors as a project requirement. The STAC also reviewed (i) the impact of magnetic field perturbations from Test Blanket Modules on ITER operation, (ii) the list of open STAC Actions from previous meetings, and (iii) the technical content of the Additional Direct Investment that will be submitted by ITER for approval at the upcoming Council meeting (IC-6).

A small triumph was that the STAC completed its report by the end of the meeting and finalized its form less than a week later. This report will be submitted to the sixth meeting of the ITER Council (IC-6), to be held June 16 and 17 in Suzhou, China.

Participants at the STAC-8 meeting from China, European Union, India, Japan, Korea, Russian Federation, and United States (photo courtesy of Prof. Ding Li)

BPO Topical Group Highlights

The BPO Confinement and Transport Topical Group seeks to facilitate U.S. efforts to understand and predict particle, momentum, and energy confinement in the plasma core region through a combination of experimental and theoretical studies (the leaders are John Rice and George McKee with Edward Doyle recently completing his leadership term). This month's research highlight from John Rice and colleagues describes their recent work to understand the causes and consequences of toroidal rotation in tokamaks.

Observations of Toroidal Rotation Drive without External Momentum Input

John Rice, Yijun Lin, Matthew Reinke, Yuri Podpaly, Steve Wukitch, Greg Wallace, and Ron Parker (MIT)

Toroidal and poloidal flows and gradients are beneficial in confined plasmas because they can suppress instabilities across a range of scales, reducing plasma turbulence and transport, and allowing higher plasma pressures to be obtained. In most tokamak experiments, toroidal plasma flow is driven by externally injected neutral beams, though in some cases, flow can also appear spontaneously without direct momentum input. However, in reactor scale devices like ITER, the neutral beams will likely not be adequate to drive sufficient plasma flow to suppress turbulence. Experiments at Alcator C-Mod are focusing on intrinsic rotation and radio frequency wave driven flow.

A new imaging x-ray spectrometer has allowed unprecedented measurement of toroidal rotation. The spontaneous/intrinsic rotation in enhanced confinement plasmas is mainly aligned with the plasma current, and has a relatively simple parameter dependence, with the magnitude of the core velocity proportional to the stored energy normalized to the plasma current. The co-current rotation is observed to propagate in towards the center from the plasma edge following the transition to the high confinement mode (H-mode) of operation, on a time scale similar to the energy confinement time. The profile shapes range from relatively flat to centrally peaked, which, in the latter case, is indicative of the presence of an inward momentum convection or pinch. An example of a velocity profile exhibiting peaking due to an inward co-current pinch is shown in Fig. 1. The velocity gradient region is typically large in the outer 2/3 of the plasma radial profile.

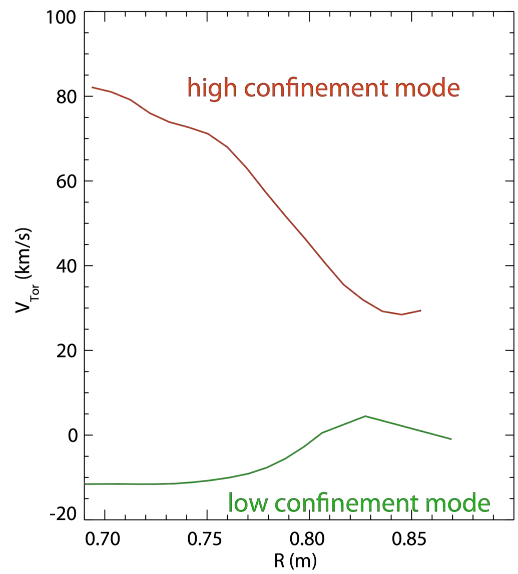

Fig. 1. Recent x-ray spectrometer data yields the radial profile of toroidal velocity in C-Mod during high and low confinement mode operation.

Intrinsic plasma rotation, however, is not well understood and does not allow simple external control. Therefore, tokamak researchers around the world have been pursuing other means to drive plasma flow, particularly via externally launched radio frequency (rf) waves. At the C-Mod tokamak, it has been demonstrated for the first time that significant toroidal and poloidal plasma flow can be driven by rf waves. In the experiments, waves with a frequency of 50 MHz are launched into plasmas consisting of deuterium and helium-3 (^{3}He), and a magnetic field of ~5.1 Tesla. The rf wave undergoes a process called “mode conversion” inside the plasma. During the mode conversion process, the launched rf wave slows down, the wavelength becomes shorter, and the wave is converted from the launched fast wave into a pair of slow waves, the so called ion cyclotron wave and ion Bernstein wave. When the amount of the helium-3 ions is at an optimal level, these shorter wavelength wave modes can interact with the plasma ions and generate plasma flow, dubbed mode conversion flow drive (MCFD). Using this method, rotation velocities up to 100 km/s have been generated, also in the same direction as the plasma current. Shown in Fig. 2 is a comparison of the MCFD results with the intrinsic rotation scaling. Unlike the intrinsic rotation that depends on underlying transport mechanisms and plasma performance, MCFD has several external control knobs for manipulating the rotation level. The rotation can be regulated by plasma parameters such as the magnetic field, ^{3}He concentration, electron density and plasma current, in addition to rf properties such as the power level, frequency and wave phase.

Another method for rf flow drive is to utilize higher frequency waves [4.6 GHz, lower hybrid current drive (LHCD)] which couples power to high energy electrons. These waves have been found to generate substantial rotation in the opposite direction, counter to the plasma current. Shown in Fig. 3 is a rotation velocity profile which is strongly peaked in the counter-current direction, produced using these microwaves. It turns out that these higher frequency waves, which generate counter-current rotation, can be used in conjunction with the lower frequency waves, which drive co-current rotation, in order to produce complicated rotation velocity profiles which are hollow in the core. This may turn out to be a useful tool for regulating transport.

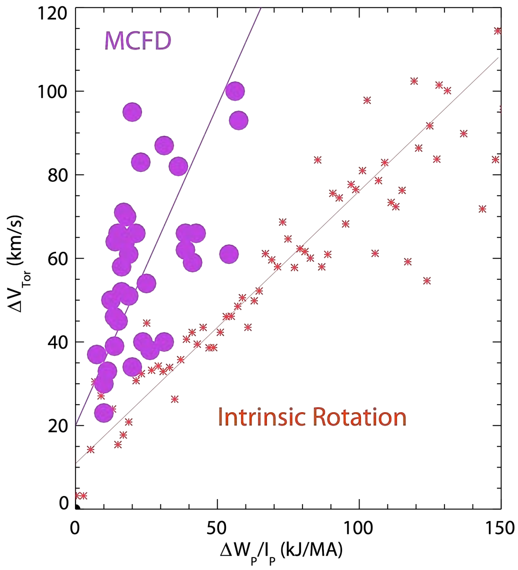

Fig. 2. Increase in peak toroidal velocity versus stored-energy / plasma-current for Mode Conversion Flow Drive (purple) and intrinsic rotation (red) without MCFD.

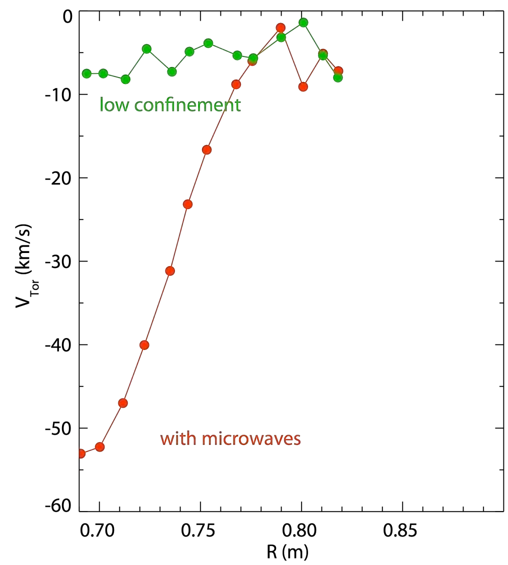

Fig. 3. Radial profile of toroidal velocity in C-Mod during LHCD (red) compared to the profile in the low confinement mode without LHCD.

REPORTS

Summary of the April ITER TBM Workshop

Erol Oktay (OFES)

The Workshop on 'TBM Impact on ITER Plasma Physics and Potential Countermeasures' was held in Cadarache, France on April 13-15, 2010. The meeting was organized by the ITER organization (IO) to assess the impact of Test Blanket Modules (TBMs) on ITER physics operations and to consider countermeasures. The primary impact is due to the magnetic ripple introduced by TBM massive ferromagnetic structures, and the potential available countermeasures include a reduction of ferromagnetic mass, increasing the recession of TBM from the plasma, and using correction coils. About 45 representatives participated from the IO, TBM teams, international plasma physics community, India Domestic Agency, TBM Program Committee (PC), and the ITER Science and Technology Advisory Committee (STAC). This workshop provided a very productive JOINT discussion between the fusion scientists and TBM experts for the first time on this complicated and important issue.

Three sets of experimental results were discussed during the physics session. These results were from the past ripple experiments on JET and JT-60U, and the recently completed DIII-D 'ITER TBM Mock-up' experiment conducted by an international team led by General Atomics last December. The DIII-D experiment, which was requested by the IO, was designed specifically to address the impact of ripple on plasma performance so that the IO can provide guidance to the TBM teams on their design of TBMs. All of these past and present ripple experiments were discussed extensively at the workshop with the following basic conclusion: The impact of ripple is negligible in low performance and low pressure (beta) plasmas; however the plasma performance is degraded in high beta plasmas as the ripple increases, potentially jeopardizing the first priority ITER mission, which is to achieve fusion gain Q~10 plasmas. These experiments also show that ripple impacts plasma rotation, density pump out, and fast particles. The ripple theory and modeling are not mature, and the predictive capability is lacking to quantify the impact of these issues on ITER performance.

In order to mitigate the ripple issue, the TBM teams have been evaluating the impact of ferromagnetic mass reduction and TBM recession on their technical objectives. Each team presented their findings on the second day, as well as a conceptual design of correction coils. A general conclusion from most of the TBM teams is that a reduction in the TBM ferromagnetic mass would jeopardize their technical objectives. Increasing the recess of TBMs from the plasma surface would help some, but its impact on neutron flux on TBMs and shielding of toroidal field coils need to be assessed.

In the final session, the results from these two sessions were further discussed to develop a set of workshop consensus, recommendations, and action items. An initial consideration is to deploy TBMs on ITER with the first plasma until the beginning of Q=10 campaign with high beta plasmas. If experiments during the early period indicate that TBM ripple would jeopardize the Q=10 mission, the TBMs would be replaced by stainless steel 'dummy' TBMs. The implication of this scenario needs to be evaluated in the context of the ITER Research Plan. The workshop recommended a continuation of the DIII-D experiments in order to study further plasma rotation and lock-mode issues in higher beta plasmas, and a repeat of these experiments on JET in order to investigate the impact of periodic toroidal coil ripple with the local TBM ripple on the same device.

Status of Fusion Energy Sciences' Joint Facilities Research Target 2010 on Thermal Transport in the Scrape-off Layer

Rajesh Maingi (ORNL/NSTX/Coordinator), Brian LaBombard and Jim Terry (MIT/C-Mod), Charles Lasnier (LLNL/DIII-D), and the 2010 JRT Team

Beginning in 2008, the DOE Office of Fusion Energy Sciences asked the three major domestic fusion facilities Alcator C-Mod, DIII-D, and NSTX to coordinate a yearly set of common experiments aimed at critical scientific questions that impact the extrapolability of results from present day devices, especially toward ITER. These specially focused experiments have become known as Joint Research Targets (JRT). For FY 2010, the JRT focuses on scrape-off layer transport, with the following wording:

> *"Conduct experiments on major fusion facilities to improve understanding of the heat transport in the tokamak scrape-off layer (SOL) plasma, strengthening the basis for projecting divertor conditions in ITER. The divertor heat flux profiles and plasma characteristics in the tokamak scrape-off layer will be measured in multiple devices to investigate the underlying thermal transport processes. The unique characteristics of C-Mod, DIII-D, and NSTX will enable collection of data over a broad range of SOL and divertor parameters (e.g., normalized collisionality ν^*, ratio of thermal to magnetic pressures β, parallel heat flux $q_{||}$ along the magnetic field, and divertor geometry). Coordinated experiments using common analysis methods will generate a data set that will be compared with theory and simulation."*

In preparation for these experiments, all three devices commissioned and/or upgraded new diagnostics to measure the divertor heat flux with sufficient time resolution to separate steady and transient power loadings. The principal focus of the research plan at each facility is to obtain an accurate set of divertor heat flux and plasma boundary layer profile measurements over the (wide) available range of externally controlled engineering parameters. Of particular interest is the dependence of the heat flux width on plasma current, heating power, magnetic field, and device size. Previous experiments have shown that the divertor heat flux footprint narrows with plasma current, and depends only weakly on toroidal magnetic field and heating power when the scrape-off layer (SOL) plasma outside the magnetic separatrix is in either the high particle recycling regime or the sheath-limited heat transport regime. The new experiments are aimed at confirming and extending those previous results for each regime. Divertor target heat flux data is being analyzed using 2-D thermal analysis tools that compute surface heat flux from calibrated measurements of the increase in surface temperature. It is important to note that C-Mod operates with refractory metal divertor targets (Mo and W) in a “closed” divertor shape with a nearly vertical outer target. The DIII-D and NSTX divertors are operated in “open” geometries. The DIII-D targets are horizontal ATJ graphite tiles, while the NSTX targets are horizontal lithium-coated ATJ graphite tiles. Additionally, the Liquid Lithium Divertor (LLD) has just been installed in NSTX, so that part of its divertor target is now liquid Li. While the differences in the three machines’ divertor geometries and materials may not affect the parallel heat conduction physics, they could affect the details of how the divertor heat flux is “mapped” to the midplane, as well as the associated divertor detachment physics and the complexity of the IR emission measurements.

In addition accessing previous data, a set of coordinated experiments among the three facilities have been planned and are being carried out. These experiments will allow the individual data sets to be joined together and compared directly over parameter ranges in which they overlap. These coordinated experiments are based on matching plasma physics dimensionless quantities ν^*, β, and normalized ion gyroradius ρ^* in the plasma edge region. A true identity experiment also matches scaled shapes of the magnetic equilibrium (poloidal flux-surfaces), e.g. elongation κ, triangularity δ, edge safety factor q_{95}, and inverse aspect ratio ε=a/R, where a and R are the minor and major radii, respectively. A true identity experiment between C-Mod and DIII-D was planned since the aspect ratio can be matched, as achieved previously in a so-called pedestal similarity experiment [D.A. Mossessian, et al., *Phys. Plasma* **10** (2003) 689]. The basic idea is to match these dimensionless parameters at the magnetic separatrix, and possibly at the top of the pedestal (several centimeters inside the separatrix), to determine if the SOL profiles and scale lengths also match. Then scans about these points allow for dimensionless parameters scans within each machine. Although NSTX has a different aspect ratio, it will contribute to these coordinated experiments in the next few months by running the same poloidal cross-section, i.e., an aspect ratio scan. Presently, the C-Mod and DIII-D portion of this experiment have been carried out, and those data are being analyzed.

Theory and modeling of some of the key transport issues affecting the heat flux widths are being carried out in close concert with the experimental measurements. This includes turbulence simulations, neoclassical transport modeling, and fluid transport modeling of varying complexity. Presentations about these on-going efforts were made at the April meetings of the Edge Coordination Committee and the US Transport Task Force in Annapolis, MD. A number of papers on the theory and experimental efforts were also presented at the 19th International Plasma-Surface Interactions Conference on May 24-29 in San Diego.

The first two quarterly status reports for the 2010 JRT are available at the DOE OFES website as http://www.science.doe.gov/ofes/performancetargets.shtml as well as JRT reports from previous years. Following the completion of this JRT at the end of FY10, final summary of the results will appear in *eNews*.

Summary Report of the Meeting of the ITPA Topical Group on Transport and Confinement at Culham, UK

Stan Kaye (PPPL)

The fourth meeting of the ITPA Transport and Confinement Topical Group was held in Culham Laboratory, UK, on March 22-25, 2010. In attendance were approximately 40 participants from the US, EU, Japan, Korea, Russia and the IO. There were a number of remote participants and presentations as well. Topics covered during the meeting were: rotation and momentum transport, impurity transport, Internal Transport Barrier (ITB) physics, physics model validation, and the Joint Expt TC-2 (hysteresis and access to high-confinement regimes with confinement factor of H~1). Results and discussion for these topics are summarized in the paragraphs below.

Rotation and momentum transport: This session focused on two topics: intrinsic rotation and momentum transport. Intrinsic rotation studies on ASDEX-U were carried out using electron cyclotron heating (ECH), finding counter-current rotation peaking with central deposition. With ion cyclotron radio frequency (ICRF) heating on JET, counter-current rotation was also observed, but did not exhibit scaling with plasma pressures observed in other devices. Tore-Supra adjusted the edge magnetic ripple and found that the resulting ion loss led also to counter-current rotation, and that subsequent ICRF or lower hybrid (LH) heating changed the rotation only in the core. There were questions raised as to whether it was valid to identify the rotation as "intrinsic", in light of torque due to particle loss with RF heating. There were additional presentations on observations of intrinsic rotation in CSDX, potential fluctuations in TJ-II, drag due to ion-neutral collisions, and reports on Joint Experiments. The Momentum Transport presentations discussed the determination and scaling of momentum diffusivity and inward pinch derived from results on a number of devices, specifically in joint experiments on NSTX, DIII-D and JET, each of which performed collisionality scans to determine the relation between particle and momentum radial transport coefficients. The data indicate weak relation between χ/v, the ratio of momentum diffusivity to pinch velocity, with collisionality on DIII-D and NSTX, and the JET results showed that the particle and momentum pinches have an opposite dependence on collisionality. There was a discussion of the momentum database as well as on the methodology to determine the momentum transport coefficients.

Core Impurity Transport: This session reviewed and compared recent and past observations in the different devices with particular emphasis on He transport. The aim was to identify common generic features that have to be understood and predicted by theoretical modeling. Modeling of turbulent impurity transport indicate that turbulent convection can reverse direction depending on the type of turbulence, and that a total convection directed outwards is usually difficult to obtain in simulations of plasma conditions at which it is observed, particularly for impurities like boron or carbon. Helium transport was determined in DIII-D, and the diffusivity was found to be gyroBohm-like in the core, but Bohm-like farther out in radius, similar to the results for the thermal diffusivity. Particle diffusivities of impurities in JET are always significantly higher than the neoclassical level, while convection velocities are near neoclassical levels in the core in H-mode plasmas. This level of the diffusivity is consistent with results from C-Mod, which also indicate even greater impurity diffusivities during the low (L) and intermediate (I) confinement modes. Results from Tore-Supra also indicate larger than neoclassical impurity diffusion and that the impurity transport is dominated by electron drift wave turbulence in the core of the plasma. In the outer half of the plasma, the transport is dominated by ion turbulence. In contrast, in the low aspect ratio NSTX device, the impurity transport appears to be consistent with neoclassical theory, including the impact of rotation on neoclassical transport.

Internal Transport Barriers (ITB): The session was divided into electron and ion ITB presentations. Electron ITBs in NSTX require strong negative magnetic shear to form; the negative shear leads to a reduction in turbulence identified as electron temperature-gradient (ETG) modes and its associated transport. The development of electron ITBs in MAST and JET are also associated with strong negative shear. Electron density ITBs in TCV, JET and JET60-U are associated with electron temperature ITBs, and are also seen when the magnetic shear is strongly negative. Work was presented on mechanisms giving rise to "canonical" pressure and rotation profiles. Ion ITB formation in C-Mod is very sensitive to both magnetic field and ICRF resonance location, with significant ExB shear measured at the ITB foot location. JET also reported the importance of strong ExB shear for an ion ITB Advance Tokamak (AT) scenario. Also reported from JET was the reduction of ion profile stiffness with high rotation gradient and low magnetic shear, and it was suggested to re-examine the common ExB quenching rule with an alternative version of this rule based on Resistive Ballooning, which is found to be more consistent with JET results. LHD plasmas showed both a reduction of ion-scale turbulence and thermal conductivity inside the ITB, consistent with gyrokinetic predictions of ion temperature-gradient (ITG) mode stabilization in this region.

Transport Model Validation: This was the first meeting of those involved in this designated ITPA Joint Activity. Presentations showed quite clearly that standard, published models fail to reproduce the evolution of the full electron temperature (T_e) profile, and, thus, time evolution of the internal inductance, l_i, (critical for ITER) during the ramp-up phases of both ITER-Demo-like discharges as well as standard discharges. The lack of agreement in the outer region of the plasma appears most significant, which is where the current profile has the biggest impact on l_i. Only with ad-hoc modifications of these models can agreement be achieved, but these modifications leave little confidence for extrapolation. The group will move forward in a two-pronged effort. It was found that T_e profiles in the outer region of the plasma are essentially linearly decreasing as a function of poloidal flux for ITER-Demo discharges from a range of devices, and these can be used as a basis to probe heating and confinement requirements needed to achieve ITER target profiles. Longer-range plans include the detailed testing of both published models and more first-principles, gyrokinetic calculations.

High-Confinement Regimes with H~1: These regimes arise shortly after the L-H transition. Various experiments reported on these results, and it was clear that no specific recipe for obtaining this confinement regime without Type I edge-localized modes (ELMs) exists. Several presentations were given on the I-mode, which has H-mode like energy confinement (0.8-1xH), but L-mode like particle confinement, and, therefore, no ELMs. The I-mode can be obtained only at high power in, so far, a counter-injection plasma; these powers are higher than those required for transition into the H-mode with co-injection, making the I-mode presently not relevant for reactor scenarios. It was felt, that there is much physics to be learned from the I-mode, specifically in its subsequent transition to the H-mode and possibly as the first step in the L-H transition process.

The next meeting of the ITPA Transport and Confinement group will be following the IAEA FEC in October in South Korea.

Announcements

Submit BPO-related announcements for next month's eNews to Tom Rognlien at trognlien@llnl.gov .

Upcoming Burning Plasma Events

2010 Events

June 20-24
37th IEEE International Conference on Plasma Science (ICPOS 2010)
Norfolk, Virginia USA

June 21-25
37th European Physical Society Conference on Plasma Physics
Dublin, Ireland

June 28-29
ITPA Coordinating Committee Meeting
Cadarache, France

Aug 30-Sept 3
Theory of Fusion Plasmas Joint Varenna-Lausanne International Workshop
(abstracts due June 18)
Varenna, Italy

Sept 7-10
3rd EFDA Transport Topical Group Meeting combined with the
15th EU-US Transport Task Force Meeting
Registration/abstract deadline is July 15.
Cordoba, Spain

Sept 27-Oct 1
26th Symposium on Fusion Technology (SOFT2010)
Porto, Portugal

Oct 11-16
23rd IAEA Fusion Energy Conference
Daejeon, Korea

Week of Oct 18-20
ITPA Energetic Particles Topical Group Meeting (in conjunction with IAEA FEC)
S. Korea

Week of Oct 18-20
ITPA Transport and Confinement Topical Group Meeting (in conjunction with IAEA FEC)
S. Korea

Week of Oct 18-21
ITPA Divertor and SOL Topical Group Meeting (in conjunction with IAEA FEC)
S. Korea

Week of Oct 18-21
ITPA Integrated Operation Scenarios Topical Group Meeting (in conjunction with IAEA FEC)
S. Korea

Week of Oct 18-21
ITPA MHD Topical Group Meeting (in conjunction with IAEA FEC)
S. Korea

Week of Oct 18-21
ITPA Pedestal and Edge Physics Topical Group Meeting (in conjunction with IAEA FEC)
S. Korea

Week of Oct 18-22
ITPA Diagnostics Topical Group Meeting (in conjunction with IAEA FEC)
Japan

Oct 24-29
9th International Conference on Tritium Science and Technology
Nara, Japan

Nov 7-11
19th Topical Meeting on the Technology of Fusion Energy (TOFE 2010)
(embedded with 2010 ANS Winter Meeting)
Las Vegas, Nevada USA

November 8-12
52nd Annual Meeting of the APS Division of Plasma Physics
abstracts due 5pm EDT July 16
Chicago, Illinois USA

Dec 15
IEA-ITPA Joint Experiments Planning Meeting
Videoconference

2011 Events

Spring
ITPA Transport & Confinement Topical Group Meeting (following US/EU TIF)
San Diego, California 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.