eNews

March 15, 2010 (Issue 42)

CONTENTS

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 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

ITER Meetings

Last month, we noted that the ITER Council would be holding a Heads of Delegation plus One (HOD+1) Meeting on February 23 and 24 in Paris. Senior representatives from all seven ITER Members participated at this meeting. The US participants were Dr. William Brinkman (Director, DOE Office of Science) and Dr. Edmund Synakowski (Head, Office of Fusion Energy Sciences). According to an article about the meeting by ITER Director-General Kaname Ikeda in the most recent *ITER Newsline*, the purpose of the meeting was to review progress that has been made by ITER and the Domestic Agencies on identifying and mitigating risk factors in the integration schedule for construction of the facility. DG Ikeda stated: "The Members were pleased to note the progress made, and gave us their full support to move ahead." The updated schedule now goes to the Management Advisory Committee of the ITER Council for consideration at a special meeting March 10 and 11 in Cadarache.

The HOD-plus-One Meeting also made the following decisions:

- The date for the next meeting of the Science and Technology Advisory Committee (STAC-8) would be shifted one week earlier, to May 10-12.
- The date for the next regular meeting of the Management Advisory Committee (STAC-8) would also be shifted earlier, to May 12-14.

These dates are in process of being confirmed through consultation among the Members.

ITER Integrated Modeling

The ITER Integrated Modeling Expert Group is preparing to hold its second meeting, probably during the week of September 20, 2010. For additional information, please contact Wayne Houlberg (Wayne.Houlberg@iter.org).

ITER Workshop on Test Blanket Modules

This is a repeat reminder that ITER plans to hold a workshop on "TBM Impact on ITER Plasma Physics and Potential Countermeasures," April 13-15, in Cadarache. Please contact Joe Snipes (Joseph.Snipes@iter.org) and Luciano Giancarli (Luciano.Giancarli@iter.org) for details.

USBPO Boundary Topical Group

At its March 1 meeting, the USBPO Council approved a two-part recommendation concerning the Plasma-Boundary Interfaces Topical Group: first, that its name be changed to "Pedestal and Divertor/SOL Topical Group" to better reflect the broad scope of the group; and, second, that within the renamed topical group there be formed two focus groups, one emphasizing pedestal physics and the other emphasizing divertor and scrape-off-layer (SOL) physics. The present leader (Tom Rognlien) and deputy leader (Tony Leonard) would be in charge, respectively, of the pedestal and divertor/SOL subgroups. These changes were motivated by a desire to provide more visibility for both sub-areas and better mapping to the equivalent ITPA Topical Groups, while still maintaining an integrated approach to edge physics studies. The functioning of the two subgroups and the value of coordination between them will be re-evaluated after a year.

Council Elections

The twelve members of the USBPO Council serve staggered three-year terms. Every year around this time, four members rotate off the Council. An election is held to replace two of the members, with the other two being appointed. The entire USBPO membership received a message on Friday, March 5, from the Council's Nomination Committee (chaired by John Sarff), asking that you submit recommendations for qualified candidates to him (jssarff@wisc.edu) and Council Chair Amanda Hubbard (hubbard@psfc.mit.edu) by March 26.

You might also take this opportunity to check your membership status, since only regular members of the USBPO may vote in this election. Membership is obtained by signing up for one or more Topical Groups, via the USBPO web site (www.burningplasma.org). If you are uncertain about your membership status or your email address has changed, please contact our Communications Coordinator, Jim DeKock (dekock@burningplasma.org).

Brainstorming about ELM Control

Back in November last year, the ITER Organization had sent an urgent request to all Domestic Agencies concerning the need for research and development work on ELM control in ITER. In particular, ITER was being pressed by the ITER Council to explore alternative methods for suppressing ELMs that do not involve in-vessel coils. Accordingly, we had circulated a message to our USBPO members, and almost 20 of you responded with various ideas.

In connection with this issue, one of the charges for the STAC-8 Meeting in May is to "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." Therefore, to prepare the US STAC members prior to this meeting and raise attention among US scientists to this issue, the USBPO plans to hold a community brainstorming session by videoconference in late March or early April. Presentations will be limited to 1-2 pages, with content in succinct form (e.g., bullets). The goal of the brainstorming session will be to develop a list of ideas for review. Stay tuned for details (to be circulated by email) of when and how this informal session will be held.

I should also point out that the next ITPA Pedestal Topical Group Meeting, to be held in Naka, Japan, on April 21-23, is planning to focus on ELM issues. Several participants will review the status and future direction of possible solutions for the ELM problem, with each review to be followed by a time of discussion. If you are interested in attending, please contact Phil Snyder (snyder@fusion.gat.com) and Rajesh Maingi (rmaingi@pppl.gov). The web site for the meeting is http://www-jt60.naka.jaea.go.jp/itpa-10-naka/index.html.

4th ITER International Summer School

Here's another reminder to encourage graduate students, postdoctoral researchers, and young scientists to attend this Summer School (http://w3fusion.ph.utexas.edu/ifs/iiss2010/). The curriculum will focus on magnetohydrodynamic and plasma control aspects of magnetic fusion confinement, with tutorial presentations to be given by leading experts in the world community. It's the first time this School is to be held in the US, and it probably will not return to this country for some time, so take advantage of this unique educational opportunity now. Registrations are due by April 30.

BPO Topical Group Highlights

The Pedestal and Divertor/SOL Topical Group seeks to facilitate U.S. efforts to understand and predict physical processes in this boundary region (leaders are Tom Rognlien and Tony Leonard). The group also seeks innovative design ideas, such as improvement to the divertor configuration capability with recent examples being the Snowflake and Super-X divertor concepts. This month's research highlight from Vlad Soukhanovskii describes a promising experimental test of the Snowflake configuration in NSTX.

Taming the plasma-material interface with the "snowflake" divertor configuration in NSTX

by V. A. Soukhanovskii (Lawrence Livermore National Laboratory)

"Taming the Plasma Material Interface (PMI)" – the interface between a hot plasma and a material surface in the presence of high neutron fluxes - is one of the outstanding challenges for magnetically confined fusion energy (MFE) research. A present vision of the PMI is a poloidal magnetic divertor, a magnetic configuration that enables energy and particles lost due to radial transport and MHD phenomena from the confined core plasma to be directed along open field lines in the scrape-off layer (SOL) to the divertor chamber. The divertor surface must be able to withstand steady-state heat fluxes up to 10 MW/m^2 (a limit imposed by the present day divertor material and engineering constraints) with minimal material erosion. The divertor interface must be also able to provide particle control and density pumping capabilities. In spherical tokamaks (STs), the compact divertor geometry and the requirement of low core electron collisionality ν_e^* to obtain adequate neutral beam current drive efficiency at electron densities n_e < 0.5-0.7 n_G (where n_G is the Greenwald density) imposes even greater demands on divertor/first-wall particle and heat flux handling.

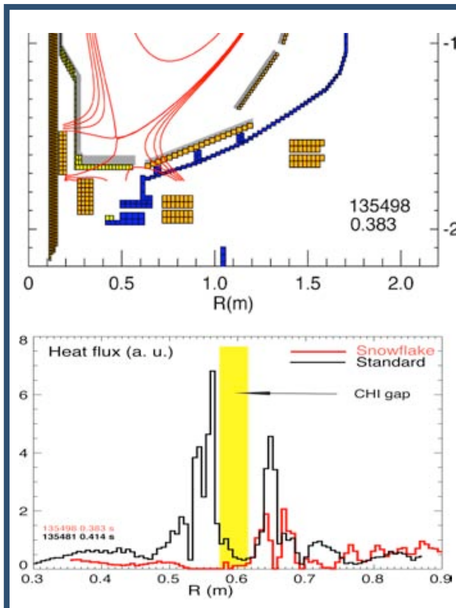

Fig. 1. (Top) The "snowflake" divertor configuration obtained in NSTX with 3 mm flux surfaces shown; (bottom) divertor heat flux profiles measured by IR camera in discharges with a standard, medium-triangularity divertor (black) and with the "snowflake" divertor configurations (red).

While the conventional X-point poloidal divertor concept has existed for 3 decades, a very recent theoretical idea and supporting calculations have indicated magnetic topologies with favorable characteristics, e.g., the "snowflake divertor" (SFD) [1, 2]. This magnetic topology was recently realized in the National Spherical Torus Experiment (NSTX), resulting in divertor peak heat flux reduction and impurity control. The highly encouraging results from NSTX given here provide further support that the "snowflake" divertor configuration may be a viable PMI concept for future ST-based devices for fusion development applications.

In recent NSTX experiments with the SFD configuration, a reduction in peak divertor heat flux due to a partially detached strike point region, and a significant reduction in core carbon density and radiated power are observed. The SFD configuration properties are studied in 0.8 MA, 4-6 MW NBI-heated H-mode discharges. These initial experiments confirm the attractive SFD PMI properties predicted by analytic theory [1, 2] and two-dimensional multi-fluid numerical modeling [3]. The SFD concept creates a second-order null in the poloidal magnetic field by merging, or bringing close to each other, two first-order magnetic X-points of a standard divertor configuration. The possibility of forming the SFD configuration has been demonstrated through magnetic equilibria modeling for DIII-D and NSTX [2], and in experiments on TCV device [5]. The SFD-like configuration is generated in NSTX using two existing divertor magnetic coils dynamically controlled by the plasma control system. When compared to the shape of the poloidal magnetic flux surfaces having high-triangularity (δ=0.7-0.8) for the standard divertor magnetic configuration in NSTX [4], the obtained SFD configuration with a medium triangularity (δ=0.5-0.65) has a magnetic connection length $l_{||}$ longer by factors of 1.5-2, and a divertor poloidal flux expansion f_m higher by factors of 2-3. Divertor heat flux profiles show low relative heat flux in the greatly expanded region near the outer divertor strike point during the periods of the SFD configuration (Fig. 1). Divertor radiation due to carbon impurity is significantly increased during the SFD configuration. As inferred from the spatially-resolved ultraviolet spectroscopy measurements and from collisional-radiative and Stark spectral line broadening modeling, a volume recombination region with T_e ~ 1.5 eV, $n_e > 3 \times 10^{20}$ m^{-3} develops near the poloidal magnetic null and strike point regions, suggesting an increase in volumetric momentum losses in the divertor and partial divertor plasma detachment extending several millimeters from the magnetic separatrix into the scrape-off layer (SOL), as mapped to the outer midplane. Importantly, the SFD partial detachment is obtained in reduced density discharges with lithium conditioning, in contrast to previous NSTX divertor detachment experiments that required an additional divertor gas injection [4]. The core carbon density, inventory, and radiated power are reduced by up to 50% in the SFD discharges with little degradation of H-mode stored energy and confinement time (Fig. 2).

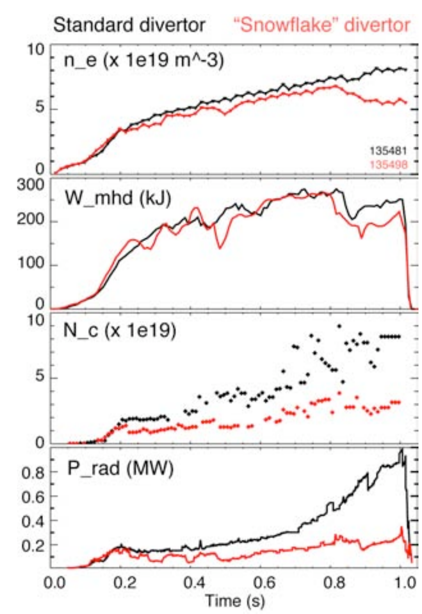

Fig. 2. Time traces of line-averaged density, plasma stored energy, plasma carbon inventory, and plasma-radiated power in discharges with a standard, medium-triangularity divertor (black) and with the "snowflake" divertor configurations (red)

Encouraged by these initial SFD results, further studies are planned on NSTX in 2010-2012. Experiments are planned to address magnetic control issues of the SFD configuration by including location of the secondary X-point in the NSTX plasma control system. Experiments are also planned to document radiative, transport and turbulence properties of the SFD, its impact on pedestal and ELM stability, as well as to explore the synergy between the high heat flux handling and impurity control by the SFD and the ion pumping by the liquid lithium divertor and lithium coatings. The ultimate goal is demonstration of a long-pulse, high plasma-beta H-mode discharge scenario with the SFD that can be extrapolated to the NSTX-Upgrade.

Acknowledgements:

D. D. Ryutov, M. Makowski, H. A. Scott, LLNL, R. Maingi, J.-W. Ahn, A. McLean, ORNL, R. E. Bell, D. A. Gates, S. Gerhardt, R. Kaita, E. Kolemen, B. P. LeBlanc, J. E. Menard, D. Mueller, S. F. Paul, A. L. Roquemore, PPPL, R. Maqueda, Nova Photonics, Inc., R. Raman, University of Washington, and the NSTX Team.

References:
[1] D.D. Ryutov, Phys. Plasmas **14**, 64502 (2007); D.D. Ryutov *et al*., Phys. Plasmas **15**, 092501 (2008).
[2] D.D. Ryutov, *et al*., Paper IC/P4-8, 22st IAEA FEC, Geneva, Switzerland, 10/2008.
[3] M.V. Umansky, *et al*., Nucl. Fusion **49**, 075005 (2009).
[4] V.A. Soukhanovskii *et al*., Phys. Plasmas **16**, (2009); Nucl. Fusion **49**, 095025 (2009).
[5] F. Piras, *et al.,* Plasma Phys. Control. Fusion **51** (2009) 055009.

This work was performed under the auspices of the U.S. Department of Energy under Contracts DE-AC52-07NA27344, DE-AC02-09CH11466, DE-AC05-00OR22725, W-7405-ENG-36, and DE-FG02-04ER54758.

REPORTS

ITER Test Blanket Module Simulated in DIII-D Experiments

by Chuck Greenfield (General Atomics)

ITER plans to include a set of Test Blanket Modules (TBMs) to evaluate techniques for breeding tritium in a reactor. The structure of the TBM modules will include ferromagnetic materials that produce a magnetic perturbation whose impact cannot be calculated with confidence by available models. A basis for predicting the resulting effects was identified by ITER as an urgent need.

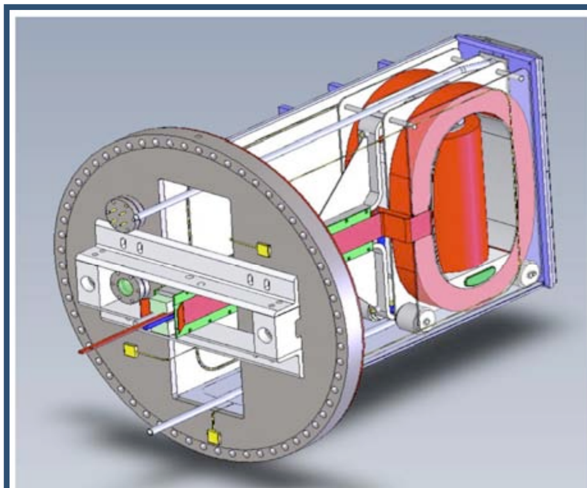

Fig. 1. The DIII-D TBM mockup

In response to this, a mockup of a single TBM pair was constructed and installed in a large port in the DIII-D tokamak. Instead of ferromagnetic materials, the DIII-D mockup relied on a set of toroidal "racetrack" (pink) and poloidal solenoid (red) coils (Fig. 1).

Fig. 2. The TBM International Team included representatives of five of the seven ITER partners (China, EU, India, Japan, and the US) and the ITER Organization.

This was not a perfect simulation. ITER will have three sets of TBMs, spaced at toroidal intervals of 40º, while DIII-D had only a single mockup. However, the current carrying capability of the mockup allows the generation of perturbations up to a factor of three larger than those expected in ITER.

An International Team (Fig. 2), representing five of the seven ITER partners and the ITER Organization and led by Mike Schaffer (GA) and Joe Snipes (ITER), carried out a set of experiments during a two-week period in November 2009 (all seven partners participated in the planning and analysis). These experiments were designed to test the TBM perturbations' impact on a variety of plasma characteristics, including H-mode access and confinement, toroidal rotation, error field correction, Resonant Magnetic Perturbation (RMP) ELM control, and fast ion behavior. Although measurable impacts were seen in all of these areas, the TBM perturbation required to see these effects was considerably larger than that expected in ITER. The most visible effect was on rotation, with toroidal rotation slowing down by as much as a factor of two (Fig. 3). However, for the perturbation strength equivalent to that expected in ITER, the change in rotation is extremely small. As also shown in Fig. 3, smaller reductions are seen in confinement.

Although the mock-up's B-field increased the sensitivity to MHD mode locking, empirical recalibration of DIII-D's error field compensation was able to completely restore the ability to avoid locked modes at low plasma β (ratio of plasma to magnetic pressures).

Studies of other plasma characteristics reinforced the conclusion that TBM perturbations comparable to that anticipated in ITER are fairly benign. The TBM field had no significant impact on RMP ELM suppression. Neutron production and fast ion loss rates were not affected within experimental uncertainty, in agreement with Monte-Carlo ion-orbit modeling.

Only with the perturbation strength increased to well above that expected in ITER did detrimental effects appear.

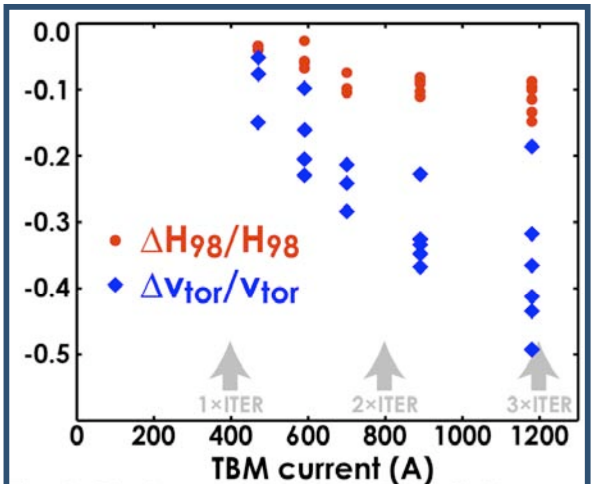

Fig. 3. The largest effect of the TBM field on co-rotating plasmas is an additional braking torque, which increases with rotation.

Although questions remain about how to extrapolate the results of a single TBM mock-up to the three pairs on ITER, these results give reason for optimism that the ITER TBM program can be carried out without detriment to ITER's main mission of demonstrating high fusion gain for an extended period of time. Additionally, the experiments and ongoing data analysis serve as a model for groups from multiple ITER parties collaborating on future issues.

Announcements

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

Upcoming Burning Plasma Events

2010 Events

March 22-25 UPDATED
[ITPA Transport & Confinement Topical Group Meeting]
Culham, UK

April 12-15
16th Joint Workshop on Electron Cyclotron Emission and Electron Cyclotron Resonance Heating
Sanya, China

April 13-15
ITER "Workshop on TBM Impact on ITER Plasma Physics and Potential Countermeasures"
Contributors contact: Joseph.Snipes and Luciano.Giancarli by **Jan. 22**
Cadarache, France

April 13-16 UPDATED **NOTE DATE CORRECTION**
U.S. Transport Task Force Workshop (abstracts due **Feb. 19**)
Annapolis, Maryland USA

April 13-16
International Conference on Plasma Diagnostics
Pont-à-Mousson, France

April 19-21
Sherwood Fusion Theory Conference (abstracts due **Feb. 16)**
Seattle, Washington USA

April 20-23
Integrated Operational Scenarios ITPA Meeting
Princeton, New Jersey USA

April 21-23
ITPA Pedestal and Edge Physics Topical Group Meeting
Naka, Japan

April 26-28 UPDATED
ITPA Energetic Particles Group Meeting
Garching, Germany

May 10-14
18th ITPA Diagnostics Topical Group Meeting (before HTPD)
Oak Ridge, Tennessee USA

May 16-20
18th HTPD Topical Group Meetings
Wildwood, New Jersey USA

May 19-21
STAC-8
Cadarache, France

May 24-28
19th International Plasma Surface Interactions Conference (abstracts due **Nov. 20**)
San Diego, California, USA

May 31-June 4
4th ITER International Summer School (abstracts due **April 30**)
Austin, Texas USA

June 20-24 UPDATED NOTE DATE CORRECTION
37th IEEE International Conference on Plasma Science (ICPOS 2010)
(abstract submission extended to **Jan. 23**)
Norfolk, Virginia USA

June 21-25
37th European Physical Society Conference on Plasma Physics (abstracts due **Feb. 27)**
Dublin, Ireland

June 28-29 NEW
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 27-Oct 1
26th Symposium on Fusion Technology (SOFT2010)
Porto, Portugal

Oct 11-16
23rd IAEA Fusion Energy Conference (U.S. synopsis due **Feb. 8**)
Daejeon, Korea

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

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

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

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

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

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

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

Week of Oct 18-22 NEW
ITPA Pedestal and Edge Physics Topical Group Meeting (in conjunction with IAEA FEC)
S. Korea

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

Dec 15 NEW
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.