



**The PPPL Highlights for the week ending October 11, 2013, are as follows:**

### **U.S. ITER FABRICATION (D. JOHNSON):**

Dates were established for System Integration Reviews for ITER port plugs E9, U11, and U14. The reviews will occur over two mornings (November 19-20) to facilitate IO remote participation. A tentative agenda has been proposed, and the IO is seeking a chair and panel members. In preparation for these reviews, the PPPL design teams have been refining concepts for diagnostic shield modules in these plugs, and assessing impacts on interfacing systems, such as the port plug structure and the diagnostic first wall.

Feedback was requested by the IO Diagnostics Division from the PPPL port plug design team on a proposal from the IO Vacuum Division for a new design of the welded lip seal on the port plugs. This new design significantly reduces the space for diagnostic components on the back of the plug. A summary of impacts will be prepared and sent to the IO.

A. Zolfaghari performed a preliminary assessment of the heating, under anticipated stray ECH loads, of the windows planned for the ITER Electron Cyclotron Emission and Low Field Side Reflectometer. Assuming conservative loading conditions, a simplified seal model, and crystal quartz window material, the heating appears tolerable for both diagnostics.

Responses were prepared for DOE comments on RFP packages for design support for the ECE and Upper Camera diagnostics.

### **NSTX (M. ONO):**

A number of NSTX-U papers were presented at the 3rd International Symposium on Lithium Applications for Fusion Devices, October 9-11, C.R. ENEA Frascati, Italy. Invited talks are presented below. Oral presentations were “Divertor deuterium recycling and oxygen influxes in lithium experiments on NSTX” by V. A. Soukhanovskii (LLNL) given by F. Scotti, “Measurements and Interpretive 2D Edge Modeling of Lithiated NSTX Discharges” by T.K. Gray (ORNL), “Erosion and re-deposition of lithium coatings on TZM molybdenum and graphite during high-flux plasma bombardment” by T. Abrams (Princeton University) given remotely, “An apparatus for the repetitive injection of spherical lithium granules into fusion research devices” by D. K. Mansfield, “A liquid dripper for fueling and ELM pacing in NSTX-U” by D. Andruczyk (University of Illinois) given by A.L. Roquemore (PPPL), and “E-beam flash evaporator for NSTX-U” by A.L. Roquemore. M. Constantin (Princeton University) gave a poster presentation on “Effect of Charge Exchange on Lithium Cooling in the Tokamak Scrape-

Off Layer near the Divertor Surface.” R. Nygren (SNL) led a special session on Lithium-Safety and Lithium Handling, and R. Goldston (PPPL) led a panel discussion on lithium feasibility for fusion reactors.

R. Maingi (PPPL) organized the program of the ITPA Pedestal and Edge Physics group meeting following the H-mode workshop in Fukuoka, Japan, October 7 – 9, and presided over a couple of sessions. In this meeting, J.W. Ahn (ORNL) presented "Progress in the study of footprint pattern with 3D fields and comparison with field line tracing in NSTX".

W. Guttenfelder and R. Perkins of PPPL visited General Atomics September 30-October 2 to participate in the DIII-D National Fusion Science Campaign experiment "Controlling H-mode particle transport with ECH" led by Darin Ernst (MIT). The experiment was carried out in QH-mode plasmas with the density profiles sufficiently peaked that the density gradient driven trapped electron mode (TEM) was predicted unstable inside  $r/a = 0.35$ , determined using between-shots linear GYRO stability analysis. With the application of ECH, decreases in the density gradient and increases in electron density fluctuations were observed, consistent with theoretical expectations. Modulated ECH and modulated gas puff perturbations were applied, and fluctuations were documented at several radii and wavenumbers from DBS, CECE, BES, ECE imaging, and PCI, while high resolution density profiles were acquired by the profile reflectometer.

M. Podestà led an experiment on DIII-D on October 4 to investigate the effect of Alfvén eigenmodes (and other plasma instabilities) on Neutral Beam current drive. Scenarios with balanced, on-axis and off-axis NB-CD have been investigated for two values of toroidal magnetic field, namely  $B_t=1.5T$  (with  $q_{min}>2$ ) and  $B_t=1.2T$  (with  $q_{min}\sim 1$ ). In both cases, toroidal Alfvén eigenmodes with  $n=4-7$  were destabilized along with lower-frequency MHD modes. Analysis has started to assess the non-inductive current profiles resulting from the different NB injection parameters and their modifications based on properties of the observed plasma instabilities.

Calculations as a function of normalized poloidal magnetic flux have been made for various configurations of the primary passive plate “Non-axisymmetric Control Coil” (NCC) as part of a General Atomics collaboration on NSTX-U. In these configurations,  $n=3$  is the only significant toroidal mode but by varying the coil pattern in the 2x12 configuration from 6 evenly spaced coils toroidally i.e., c,s,c,s,c,s,c,s,c,s where c=coil and s=space, to c,s,c,s,c,s,c,s,c,s,s a relatively well balanced  $n=3$  and  $n=4$  spectrum is produced. Other NCC configurations with reduced sets of coils are being studied in order to identify profiles to produce a broad edge stochastic layer width while falling off rapidly in the radial direction to minimize the impact of the non-axisymmetric field on the core plasma (T. Evans, General Atomics).

Preparations for plasma operations in the NSTX-U configuration continued with a successful review of the conceptual design for the proposed new plasma current calculator. Also, tests to qualify a proposed new compliant center conductor for the High Harmonic Fast Wave (HHFW) system center post are being prepared. The RF test stand is under vacuum and wave guides are in place to first baseline the original rigid center conductor, and then move to a series of tests with the compliant version.

## **ITER & TOKAMAKS (R. HAWRYLUK):**

Y. Ren participated in the ITPA Transport and Confinement Topical Group , R. Budny, and C. Kessel participated in the Integrated Operation Scenarios Topical Group meetings in Japan last week.

## **DIII-D (R. Nazikian):**

R. Hawryluk was the session leader for an experiment to simulate burn control by using non-axisymmetric fields. This experiment was part of the national campaign and included participants from General Atomics, PPPL and MIT. Preliminary observations indicate that non-axisymmetric fields can control the stored energy, which is used as a surrogate of alpha heating in a burning plasma device. The pedestal density was controlled by gas puffing using Thomson scattering data to compensate for the pumpout that accompanies the application of non-axisymmetric fields in the conditions studied. The impact on the beta limits appears to be small if any.

J. Hosea and A. Nagy worked with the DIII-D RF group members Bob Pinsker, Tony Horton and Bobby Dannels to configure the 285 Fast Wave antennae on DIII-D as a passive receiver for the Edge Harmonic Oscillation (EHO) in QH-mode plasmas. This is a first step in determining if the antenna can couple effectively to the EHO for the purpose of controlling the excitation and magnitude of the EHO. Ultimately the method could, in principle, be used to trigger access to the QH-mode regime. Preliminary results indicate that the antenna can detect the EHO and further work is underway to determine the coupling properties from the mode pickup amplitude.

## **ADVANCED PROJECTS (H. NEILSON):**

S. Lazerson visited the Courant Institute of Mathematical Science at New York University. Discussions during the visit focused on ideas and possible collaborations for improving the U.S. suite of 3D plasma analysis tools. Lazerson met with Antoine Cerfon and Jeff McFadden to discuss possible upgrades to the NSTAB 3D equilibrium code. Additional discussions with Eliezer Hameiri regarding 3D equilibrium with flow were productive as well.

Professor Francesco Volpe of Columbia University visited PPPL on October 10 to discuss opportunities for collaboration in stellarator research. Volpe attended the monthly stellarator team meeting and made a presentation, "Stellarator Research at Columbia University," describing the status and research plans for the CNT stellarator and a new experiment, Proto-CIRCUS, now under construction. The plans presented included ideas for testing plasma sensitivity to field errors and coil misalignments and for simplifying coil geometries; these plans are aligned with the long-term need to simplify stellarator designs. Discussions with PPPL stellarator physics leader D. Gates explored possibilities for PPPL contributions that could support Volpe's research.

## **THEORY (A. BHATTACHARJEE):**

This week's theory seminar titled "Magnetic reconnection process in transient coaxial helicity injection" was presented by Dr. Fatima Ebrahimi from Department of Astrophysical Sciences, Princeton University. Dr. Fatima Ebrahimi was awarded an invited talk on this topic at the upcoming APS-DPP meeting. The talk was well-received and generated fruitful discussion. Her simulations show that the reconnection process for the transient coaxial helicity injection in NSTX has a Sweet-Parker characteristics; this conclusion is based on the scaling of width of the elongated current sheet. Future research will involve detailed study of the outflows during reconnection. The abstract reads: "Non-inductive current formation and its sustainment is one of the major physics objectives in NSTX as an advanced Spherical Torus (ST). A promising candidate for start-up current formation is Coaxial Helicity Injection (CHI). We numerically examine the physics of transient CHI for start-up in NSTX. Through resistive MHD simulations, we first obtain the minimum conditions required for generating closed flux and then explain the fundamental mechanism for magnetic reconnection and closed flux generation in transient CHI discharges. We find that at sufficiently low magnetic diffusivity (high Lundquist number), and with a sufficiently narrow injector flux footprint width, the oppositely directed field lines have sufficient time to reconnect (before dissipating), leading to the formation of closed flux surfaces. Simulations show that an X point is formed in the injector region, followed by formation of closed flux surfaces within 0.5 ms after the driven injector voltage and injector current begin to rapidly decrease. As the injector voltage is turned off, the fields lines tend to untwist in the toroidal direction and magnetic field compression exerts a radial  $\mathbf{J} \times \mathbf{B}$  force and generates a bi-directional radial Etoroidal  $\times$  Bpoloidal pinch flow to bring oppositely directed field lines closer together to reconnect. The reconnection process is shown to have transient Sweet-Parker characteristics ([http://pop.aip.org/resource/1/phpaen/v20/i9/p090702\\_s1](http://pop.aip.org/resource/1/phpaen/v20/i9/p090702_s1) ). There are similarities between the transient Sweet-Parker reconnection found here and that reported in forced-reconnection laboratory plasmas of MRX. "

## **ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):**

### **NSTX Upgrade (R. Strykowski, E. Perry, L. Dudek, T. Stevenson):**

Construction: The upper outer TF supports have been completed and the installation of the lower supports is in progress. All items installed on the Bay L port cover so far have passed leak check. The installation of the MPTS ports at bays L and FG is in progress. Since all individual items welded to the vessel during this outage have passed leak checks there is no need for a pumpdown in January to do a pre-leak check. Work on turnbuckle spaces and PF5 supports continue. Power has been restored to all racks in the NSTX test cell. The old lower ceramic break has been removed from the vessel.

CS Assembly: The TF bundle successfully passed its electrical tests this week, marking a major milestone for the Centerstack Upgrade. Electrical isolation was found to be very good at 1kV between conductors and at 4.5kV from quadrant to quadrant. Preparations are now underway to lift the TF bundle into the vertical position for the application of the Aquapour base for OH winding. The prebid meeting for the procurement of the TF Lead Extensions was held this week, four qualified vendors participated in the teleconference. The OH Winding station in the CS Coil Shop is undergoing final alignment, reels of copper have been loaded into the winder

to use for testing purposes. The weld rework on the tile studs on the CS casing was completed this week. The Tech-Shop has been fabricating the NSTXU buss bars and other small parts needed to start the OH winding. The CS Ceramic break assembly is being preassembled to test fit up of parts and to identify potential interferences with existing hardware.

NBI Upgrade: Decon of the TTC East wall for cable tray installation was completed to the degree required for cable tray support installation. Hole drilling and stud installation in TTC East wall for the supports has started. The supports have been moved to D site. DI Water flanges have been made and installed on pipe ends in NTC; hydros are planned next week. The Ion Source and Ion Dump DI H<sub>2</sub>O Pump procurement continues. BL2 alignment of 90-inch flange, OMA scrapers, and source platform rails continues. The power system cable and tray subcontract installation work has started in the TCB. Scanning for wall and ceiling mounts continues. Thermocouple fabrication for the armor tiles continues. Final welding of t-bar studs is in progress when welding is available. Planning for VV leg modification and duct installation continues. Management conducted job status reviews.

#### **Facilities and Site Services (M. Viola, M. Donohue, F. Cargill):**

The Lyman Spitzer Building has been recognized by the Department of Energy for performance in meeting the five High Performance Sustainable Building Guiding Principles for FY13.

#### **DIRECTOR'S OFFICE (C. AUSTIN):**

On October 9, Professor Jennifer Francis from Rutgers University presented a colloquium entitled, "Effects of a Rapidly Warming Arctic on Weather Patterns in Mid-Latitudes".

#### **INVITED TALKS:**

“Radiative liquid lithium divertor concept” by M. Ono, 3rd International Symposium on Lithium Applications for Fusion Devices, October 9-11, C.R. ENEA Frascati

“High-temperature, liquid lithium plasma-facing component research for NSTX-U and next step device” by M. A. Jaworski (PPPL) given remotely, 3rd International Symposium on Lithium Applications for Fusion Devices, October 9-11, C.R. ENEA Frascati

“Lithium sputtering from lithium-coated graphite plasma facing components in the National Spherical Torus Experiment (NSTX) divertor” by F. Scotti (Princeton University) 3rd International Symposium on Lithium Applications for Fusion Devices, October 9-11, C.R. ENEA Frascati

Dr. W. Tang presented an invited plenary talk on "Magnetic Fusion Energy Simulations at Extreme Scale" at the International Jacobi High Performance Computing (HPC) Mathematical Models & Algorithms Conference, Kaliningrad, Russia, October 4-6.

On October 8, N. Fisch delivered a plenary talk at the International Electric Propulsion Conference, in Washington, DC. The lecture, at a tutorial level, was titled, "Principles of Rotating Plasma in Plasma Propulsion Systems."

### **PUBLICATIONS:**

A paper titled "Non-axisymmetric magneto-hydrodynamic equilibrium in the presence of internal magnetic islands and external magnetic perturbation coils" by B. Tobias et al. has been accepted for publication in Plasma Physics and Controlled Fusion. The paper documents the nonlinear excitation of the external kink mode by both external error fields and internal MHD.

### **COLLOQUIA**

M. Okabayashi presented a colloquium at Columbia University on "Avoidance of Neoclassical Tearing Mode Locking by Electro-Magnetic Torque Feedback on DIII-D". Experiment demonstrated that feedback with sufficiently high gain can sustain the  $m/n=2/1$  neo-classical tearing mode rotation and avoid disruption.

S. Lazerson visited the Courant Institute of Mathematical Science at New York University and presented a seminar entitled "3D Equilibrium Reconstruction for Stellarators and Tokamaks."

### **LEADERSHIP POSITIONS:**

R. Maingi (PPPL) was selected as chair of the ITPA Pedestal and Edge Physics group, succeeding the outgoing chair, N. Oyama

This report is also available on the following web site:  
<http://www.pppl.gov/publication-type/weekly-highlights>