PRINCETON PLASMA PHYSICS LABORATORY
WEEKLY highlights

PPPL
U.S. DEPARTMENT OF ENERGY

**The PPPL Highlights for the week ending November 1, 2013, are as follows:**

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

A draft Statement of Work for Physics and Engineering Design Support for ITER Toroidal Interferometer/Polarimeter (TIP) Front-End and Provision of Optical Relay and Diagnostic Hall Components was circulated for PPPL internal review. The TIP system uses five tangential sight lines with retro-reflectors located on the ITER outer wall. The outermost sightline is at an extreme angle to the wall surface, resulting little shielding between the plasma and the retro-reflector. Under consideration is an IO proposal that would allow active cooling for the optics in this location.

Pre-proposal teleconferences were held for RFPs for the design and fabrication support for the ITER ECE and Upper Camera diagnostics.

## NSTX (M. ONO):

Several enhancements and updates were made to the NSTX-U H-mode pedestal analysis software. An ability to include the fast ion pressure computed with the TRANSP transport code into the MHD equilibrium pressure profile was added which significantly improved the quality of the equilibrium fits. A new model for the bootstrap current based on results from the XGC0 code was added to the equilibrium reconstruction tool; in addition, an overall scale factor for the bootstrap current was added to the kinetic EFIT tool. A number of improvements were made to the codes to simplify their application including simplification and consolidation of the code run control tables, improved auto-knotting for the spline fits, and improved documentation. Several improvements in the visualization tools for equilibrium reconstruction and profile analysis were made. An iteration scheme was implemented which remaps the pressure profile in the kinetic EFIT to bring it into agreement with the measured pressure profile. A similar iteration scheme was also implemented in the 'VARYPED' EFIT equilibrium generation. The VARYPED EFIT mode is used to create a grid of variations in pedestal current density and pressure keeping the plasma beta fixed for pedestal stability analysis with ELITE. In the new iteration scheme the profiles are renormalized to the total stored energy and plasma current based on the flux geometry of the varied equilibrium. This gives a more rectangular variation grid and keeps the overall plasma beta fixed. The rotation profiles were more accurately extrapolated beyond the separatrix to allow better determination of the zero crossing for the radial electric field. A provision was added to allow reconstruction of the impurity density profile from the carbon density rather than the Zeff profile. (Tom Osborne, General Atomics)

Preparations of non-upgrade equipment for plasma operations in the NSTX-U configuration also continued with the assembly of the second two prototypes of the Stand Alone Digitizer (SAD) modules for use by NSTX diagnostics. Testing of the first SAD prototype continues. The RF test stand is operational, and successfully completed tests to baseline the original High harmonic Fast Wave (HHFW) rigid center conductor. Tests are now being planned to qualify a proposed new compliant center conductor capable of withstanding increased NSTX-U loads.

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

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

The DIII-D 285 antenna transmission line was removed from the pit this week by a team of engineers and technicians General Atomics, ORNL and PPPL. Part of the procedure for removing the system was modified to incorporate careful documentation of the status of the transmission line by taking gas seal specimens for analysis, recording arc event locations, performing line component indexing, and more. In addition a final calibration check was performed before the lines were disconnected. No arc tracks have been discovered, no damaged quartz insulation pins were found, and the elastomer o-ring seals were found intact. All components are being held in a radiation storage area for inspection by an ORNL/ITER team scheduled after Thanksgiving. All components of this system have been conserved for reinstallation if needed at a later date.

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

In the Wendelstein 7-X (W7-X) collaboration, the first joint project meeting for the x-ray imaging crystal spectrometer (XICS) was held this week. Staff from PPPL and from Germany's Max Planck Institute for Plasma Physics (IPP) attended. The XICS will be designed and fabricated by PPPL, with engineering support and installation by IPP. The IPP Responsible Officer for the project, Dr. Rainer Burhenn, reported that the XICS has been approved as an OP1 diagnostic in the W7-X program, meaning that it is planned for the first full operating campaign. While it is intended by both sides that the equipment be available for the short first-plasma campaign (OP1.1), installation for OP1.1 is not guaranteed due to the already crowded W7-X assembly schedule. It was agreed that PPPL's N. Pablant will lead the development of a project specification, while IPP will optimize the space allocation for the XICS to maximize the field of view while minimizing the risk of interferences with neighboring equipment. A conceptual design review is planned for January 2014.

Manufacture of five DC switches for the W7-X trim coil system was completed by the supplier, Filnor, Inc. of Alliance, OH, and shipped to the project site in Greifswald, Germany. These switches provide a capability, needed for personnel safety whenever there is personnel access to the machine area, to disconnect the trim coil leads from their power supplies, and connect the coils to ground.

In PPPL's collaboration with South Korea's National Institute for Fusion Science (NFRI) on engineering analysis for a fusion nuclear facility, K-DEMO, a joint team planning teleconference was held this week. Through February 2014, the team will focus on preparation of a conceptual

studies report, a milestone deliverable within NFRI. Priorities for PPPL's efforts were identified by NFRI, emphasizing scenario development and machine configuration modeling. Dr. Kihak Im of NFRI presented a new layout of blanket and divertor components inside the vacuum vessel. Plans were made to hold an on-site project meeting at PPPL on November 19-20.

**THEORY (A. BHATTACHARJEE):**

Guiding center simulations play an important role in understanding the effect of ideal and resistive modes on high-energy particle distributions. Both injected beam particle and fusion alpha particle distributions can be significantly modified by Toroidal Alfven instabilities, producing losses and significant wall loading. Until recently, simulations of the effect of Toroidal Alfven eigenmodes (TAE) on beam distributions have taken up to several days of simulations on a single processor computer. This summer, Princeton University student Ante Qu implemented a new, highly multi-threaded GPU version of the guiding center code ORBIT under the supervision of S. Ethier and E. Feibush. The new version is 128 times faster than the old version and is currently being used for full-production simulations of induced particle loss by TAE modes in NSTX and TAE-induced avalanches. National Undergraduate Fellowship Award recipient, Ante Qu will present a poster on this research at the APS Division of Plasma Physics in Denver, Colorado on November 12 at 2:00 PM. The poster number is JP8.00025.

A paper by collaborators at the University of Saskatchewan, Canada and PPPL “Sheath-Induced Instabilities in Plasmas with E×B Drift” investigates possible mechanisms of anomalous transport in Hall thrusters. Classical inter-particle collisions alone are too weak to explain experimentally observed electron currents across magnetic field. A new instability was identified. It is shown that ion acoustic waves in plasmas of finite size with E×B electron drift become unstable due to the closure of plasma current in the chamber wall. Such unstable modes may enhance anomalous electron transport in plasma devices with E×B electron drift and unmagnetized ions. The instability is sensitive to the wall material: a high value of the dielectric permittivity of the wall material reduces the mode growth rate by an order of magnitude. This theoretical study may explain previous experimental findings that wall material may strongly affect Hall thruster operation. (see publications below for reference)

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

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

Construction: Installation of the lower supports for the outer TF legs continues, as does the installation of the associated turnbuckles. Work on the new PF 4/5 supports continues with the resolution of interferences. The lower divertor gas injection system is nearly complete.

CS Upgrade: The Aquapour layer has been installed around the TF bundle and cured. The first wet layup layer is in the process of being applied and will continue this weekend. Some testing is being performed in the coil area to confirm the effectiveness of the glass epoxy insulation in the absence of a ground plane. The first phase of testing was successfully completed by applying 15kv for 40 one-minute periods. The final phase of the test will consist of a continuous one-hour long 15kv hipot test. If successful, these tests will confirm the decision to omit the ground plane

from inside the OH coil. The OH winder tensioner brake system was modified to increase the tension capacity and is being setup to perform a second tension test to confirm the increase in tension. A replacement winch has been ordered with higher capacity to replace to original version. It will arrive on Monday of next week. The work platform was also installed around the TF bundle head stock and tail stock areas. A teleconference took place with the successful bidder for the outer TF lead extensions. The vendors plans for material procurement, electron beam welding and final machining was discussed. The procurement contract is expected to be in place early next week. The buss bar and support fabrication continues in the Tech Shop. The OH coax bus supports were being worked on this week and tests of 90-degree bends of the various sizes of conductor were being performed to confirm the tooling choices. It was discovered that a toggle clamp on the OH braze system was worn out and required replacement. The new clamp has been installed and an initial braze retest was successfully performed. The timing program for the induction brazer was also adjusted to increase the temperature soak time. All braze operators are now being requalified with the new hardware and timing cycle. A mandrel is being installed on the Ramsome winder to make a test article to measure the pull out force on the TF Bundle crown piece.

NBI Upgrade: BL2 ion source platform adjustments continued to establish the correct ride height for source enclosure installation while maintaining a good fit for source aiming sight lines. Platform modifications were made similar to those of BL1. Source enclosure fit was attempted using a spare enclosure in all three locations (ABC). With timely support from Tech Shop welding, OMA shield installations were completed. Layout and relocation of the high voltage transmission lines in NTC were evaluated and discussed. Interferences with cable tray supports at ground level were evaluated. A small NE shift of BL2 C HVE will be required. Plans are underway to adjust the placement of this HVE. TTC decon of the South wall near the SE door took place this week to further recover the area. Plans and packages for the vacuum system services continue to be developed. Small flange and valve orders were placed to support this work. The Port Extension Molybdenum shielding was evaluated for fit and adjustments made in the Tech Shop. With the completion of this final set of details, the NBI and TVPS duct leak checking and installation is imminent. Parts are also being made in the Tech Shop for the BL2 DI water system manifolds. Armor thermocouple fabrication and assembly is in progress but limited by resource availability. The Maul subcontract for power cable and tray continues with tray installation in TTC and NTC. Support location and installation is in progress.

**BUSINESS OPERATIONS (K. FISCHER):**

The Budget Office submitted PPPL's LDRD project data for FY13 into the DOE LDRD database. This data will be included in the agency's FY13 Report to Congress on Laboratory Directed Research and Development (LDRD) at the DOE Laboratories. In addition, the DOE Chicago Office (DOE-CH) must review and certify the LDRD data submitted by PPPL. Documentation requested by DOE-CH for this review has been submitted.

PPPL submitted a proposal to NASA titled "Global Kinetic Modeling of Waves and Transport in the Inner Magnetosphere." The proposed budget for the three-year proposal is $1,493,550. The principal investigator is J. Johnson.

PPPL submitted a proposal to NSF titled "GEM: Modeling Plasma Energization and Transport in the inner Magnetosphere with a Global Gyrokinetic Code." The proposed budget is $369,450 for the three-year period of performance. The principal investigator is P. Damiano.

PPPL submitted a proposal titled "GEM Collaborative Research: Investigation of EMIC Wave Propagation and Absorption Characteristics Under Different Plasma Conditions" to NASA. The principal investigator is Eun-Hwa Kim. The total budget proposed for the three-year effort is $287,400.

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

A. Cohen participated in a meeting of the ITER-MAC in Cadarache, France from October 24 - 31.

October 28 - November 1, S. Prager hosted the third general meeting of the Max-Planck/Princeton Center for Plasma Physics (MPPC). The meeting facilitated interactions within MPPC between researchers in the four center topics (reconnection, turbulence, energetic particle, magneto rotational instability). October 28 - 29 parallel working group meetings were held on each of the four center topics at Princeton Plasma Physics Laboratory, and October 30 - November 1 the general group meeting was held at Princeton University. Approximately 70 people attended the sessions, which included 27 people from Max Planck (Germany).

**PUBLICATIONS:**

Smolyakov, A.I.; Frias, W. (University of Saskatchewan); and (PPPL) Kaganovich, I.D.; and Raitses, Y., "Sheath-Induced Instabilities in Plasmas with E×B Drift," Phys. Rev. Lett. 111, 115002 (2013) http://link.aps.org/doi/10.1103/PhysRevLett.111.115002.

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