

PRINCETON PLASMA PHYSICS LABORATORY

**WEEKLY** highlights



**The PPPL Highlights for the week ending June 7, 2013, are as follows:**

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

The Conceptual Design Review for the Motional Stark Effect diagnostic was held in Cadarache, France. The Review was considered successful pending resolution of 5 Class 1 chits.

Discussions continued with the ITER blanket group on the location and geometry for the TIP retro-reflectors.

**NSTX (M. ONO):**

NSTX-U is in the Upgrade Project outage in FY 2013. NSTX Upgrade construction activities continued this week and are highlighted in the Engineering section below.

Dr. K. Kim (PPPL) made a presentation at the June 3 NSTX-U Physics Meeting entitled “Application of POCA for NTV Analysis and Field Line Tracing in the Non-axisymmetric Magnetic Perturbations”. POCA is a delta-f guiding center tracking code that has been developed to calculate neoclassical transport, including the neoclassical toroidal viscosity (NTV) in the presence of non-axisymmetric magnetic fields in tokamak plasmas. Non-axisymmetric fields are typically applied for, for instance, ELM pacing/suppression, or occur naturally from large 3D structures such as Test Blanket Modules (TBM). NTV is an important area of research as it can change the plasma rotation, impacting the stability of the plasma on both macro- and micro-scales. While previous analytic theory has captured the essence of NTV, the previous theory is missing the effects resulting from distorted particle orbits and rotational (e.g., bounce harmonic (BH)) resonances that can enhance the neoclassical radial transport. The enhanced neoclassical effects are computed by POCA after inputting the perturbed magnetic field spectrum as computed by the IPEC code, which includes the plasma response to the vacuum perturbation. The importance of the BH resonance was indeed reflected by a peak in the NTV computed at the location of the ExB precession frequency. Benchmarking against NSTX and DIII-D NTV results are just starting. NTV profiles have been calculated for the present and proposed 3D coil sets for NSTX-U, with the results indicating that a wide range of NTV profiles, and thus flexibility in controlling rotation profiles, may be expected. Finally, the field line tracing capability of the POCA/IPEC code combination provides a unique capability that incorporates all possible field components, multiple toroidal modes and plasma response to calculate field line connection length and particle loss fraction. This capability is being benchmarked against NSTX and DIII-D measurements and images of plasma lobes, divertor footprints and heat fluxes. Development will continue on all applications of the new code as

benchmarking results become available.

Preparations for plasma operations in the NSTX-U configuration also continued with the fabrication of new diagnostic port covers, the recommissioning of the three autotransformer and transformer rectifier sets that will provide the primary power for the NB2 ion sources, and the power testing of the new firing generators for the field coil power conversion (FCPC) system rectifiers.

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

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

A. Nagy successfully lead the B-coil bus extraction/lift team in removing a 1200 lb coax from the lower pit to the high bay. This lift/move took approximately 4 days of preparation and 8 hours of lift time to complete by a team of 1 engineer and 5 technicians. The lift was performed without incident. The re-installation will follow the repair welding of the B-coil bus.

#### **Alcator C-Mod (R. Ellis):**

*(see Colloquia/Publications)*

#### **I&T General (L. Zhakarov):**

*(please see Colloquia)*

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

Several papers and presentations on Department activities were prepared for the IEEE Symposium on Fusion Engineering (SOFE), to be held the week of June 10 in San Francisco. The submissions include contributions from collaborative work on the Wendelstein 7-X (W7-X) trim coils and K-DEMO pre-conceptual design. In addition, PPPL has key roles in the organization of the Symposium, including Technical Program Chair, Publication Chair, Special Issue Guest Editor, and Fundraising Chair.

In the Wendelstein 7-X (W7-X) collaboration, an order for 1,000 meters of electrical cable was placed with Top Cable S.A. The cable will connect the elements of the U.S.-supplied trim coil system, namely the power supply units, DC switches, and coils.

Physicist N. Pablant arrived at Japan's National Institute for Fusion Science to continue his collaboration on LHD stellarator transport analysis using data from the U.S.-supplied x-ray imaging crystal spectrometer (XICS). An extended highlight on this collaboration, "The Physics of Transport at Low-Collisionality in the Large Helical Device," was recently submitted to DOE-FES.

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

A theory seminar was presented by J. Parker, a PPPL Theory graduate student. He presented his work with J. Krommes on "Zonal Flow as Pattern Formation: Merging Jets and the Ultimate Jet Length Scale". Zonal flows are generally known to spontaneously emerge from turbulence by Reynold stress through a fully nonlinear process of an inverse cascade. Parker presented an alternate quasilinear approach, in which statistically homogenous turbulence transitions to an inhomogenous turbulent state with organized zonal flow structure. This transition as a function of a friction parameter was shown through quasilinear simulations of the Hasegawa-Mima equation. The results of this quasilinear approach when retaining the nonlinearity between drift waves and zonal flow was discussed. The stability diagram for these zonal flows was analyzed and compared with the simulations.

## **COMPUTATIONAL PLASMA PHYSICS GROUP (S. JARDIN):**

A successful verification benchmark has been carried out by X. Yuan and B. Grierson between the new (P)TRANSP profile advance routine PT\_SOLVER and the TGYRO and XPTOR codes. Good agreement between the three codes was obtained when each had implemented a thermal conductivity model including contributions from both the TGLF (turbulent transport) and NEO (neoclassical transport) models. An ITER Hybrid test case constructed by R. Budny that did not have a  $q < 1$  region was used in this benchmark. The simulation region extended from the magnetic axis to the edge region. The final converged ion and electron temperature profiles, as well as the separate TGLF and NEO fluxes were successfully compared for the runs, both with and without flow shear.

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

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

Construction: The 109' platform in the area of bay G is being modified to make it stiffer for the MPTS diagnostic. This work will cause access restriction on the south side of the machine for the next two weeks. The neutral beam armor mounts have been welded into the vessel. PF4/5 support modifications continue. Studs are being welded to the vessel exterior for mounting thermocouples and flux loops. Work on TF13 and TF14 is on hold while the shape and position of all TF coils is being determined. Tray is being install from the north side of the machine to the north wall.

CS Upgrade: The fourth quadrant mold has passed leak test and is being placed into the oven for VPI to occur next week. The Full TF mold has passed all tests at Reno and is expected to ship next week. Bids for the centerstack uprighting fixture are due COB June 7. At least one bid has already been received that is in our price range. The delivery date meets our requirements.

The Bussbar run Pro/E model is ready for analysis. The analysis will begin immediately after the SOFE Conference. The procurement requisition of copper materials is submitted for approval. A meeting was held to review the OTF aluminum block location discrepancies. The location of the blocks vary from coil to coil by up to 1" causing the location of the TF flags in the umbrella to be

located inward by that amount from nominal. This much difference in location for the OTF flags in the umbrella structure cannot be accommodated by the current lead extension design. The lead extensions are being modified to move the flag landing locations inward by the maximum amount mentioned above. For the OTFs that vary from the max, provision of an adjustable thickness shim will be provided.

NBI Upgrade: Installation of the magnetic shielding on the BL OMA boxes continues. Fabrication and leakchecking of LHe cryo line continues in the NB shop. LHe cryogenics line installation, welding, and leakchecking on the TFTR Test Cell East wall continues. Fabrication continues on the NB/TVPS duct components in the Tech Shop. The DI water system subcontract continues with demolition work and lifts to move piping, equipment, and supplies down to the Pump Room level. Pipe welding has started. NBI Armor fit-up and support installation in the VV continues and VV support welding is complete. JK VV reinforcements are on order. SFLIP design and analysis has been completed in preparation for an FDR and materials are on order. The monthly job status meeting was held with active jobs reporting.

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

The Procurement Division compiled the Laboratory's cumulative small business subcontracting plan results through May 31. The results are: Overall Small Business, 61.6% (Goal 50.2%); Disadvantaged Business, 4.7% (Goal 5.0%); Women Owned, 5.43% (Goal 7.0%); HUBZone, 1.89% (Goal 3.5%); Service Disabled Veteran Owned, 3.05% (Goal 3.0%). While the Laboratory is now meeting two of its five goals, budget uncertainty continues to be a drag on program performance. To the extent feasible, for the remainder of the year Procurement will place additional emphasis on sourcing in the HUBZone, disadvantaged and women owned categories.

### **OFFICE OF COMMUNICATIONS: (K. MACPHERSON):**

J. Greenwald attended the annual meeting of fusion and ITER communicators at ITER headquarters in Cadarache, France, and gave a presentation about PPPL's communications strategy. Greenwald also toured the ITER construction site and wrote a blog about the meeting for the PPPL website. The ITER Newslines posted Greenwald's piece on PPPL contributions to ITER on the Newslines home page (<http://www.iter.org/newsline/270>). Greenwald wrote stories on MINDS and TRANSP for a National Labs' web initiative.

K. MacPherson assisted reporters from The New Yorker, The New York Times, the Trenton Times, and the Princeton Alumni Weekly (PAW) with stories. She assisted in a visit by a New York Times reporter to PPPL on June 10, when the reporter toured the Lab and conducted interviews with A. Cohen, T. Stevenson, R. Sheneman, J. Levine, and M. Williams for a story on SF6 emissions reductions.

### **BEST PRACTICES & EXTERNAL AFFAIRS (J. DELOOPER):**

On June 1, PPPL hosted an Open House for the public. More than 3,000 individuals attended and got to see many parts of the laboratory. Feedback from the public was very positive.

On June 9, the Science Education department hosted a welcome dinner for the 2013 NUF/SULI/CCI interns on main campus.

### **OFFICE OF ACADEMIC AFFAIRS (N. FISCH):**

E. Granstedt successfully defended his Final Public Oral Exam on June 7, earning his Ph.D. Gilson's advisors are B. Kaita and G. Hammett.

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

On June 5, M. Zarnstorff and J. Hosea co-hosted a Research Council meeting to discuss the midyear status of LDRD projects.

On June 6, S. Prager, A. Cohen, M. Zarnstorff and J. DeLooper traveled to Washington, D.C. to attend the Laboratory Planning meeting.

### **COLLOQUIA:**

B. Mumgaard gave a talk, "Effects of Polarized Background light on MSE Measurements", at the C-Mod Science Meeting on June 3.

On May 31, L. Zakharov and X. Li visited Lehigh University and gave two talks to the Professor A.Kritz plasma physics group. X.Li described a new equilibrium solver ESC-EEC, based on flux coordinates and suitable for transport simulations with high resolution of the plasma edge limited by a separatrix. L.Zakharov in his talk on "Temperature pedestals. The Effect of Power Trapping" explained the root mistake in the widespread interpretation of temperature pedestals as so-called transport barriers. Instead, his criterion of validity of the diffusive transport gives a basis for understanding pedestals consistent with experimental data. For the first time the effect of power trapping, which may explain the L-to H-mode transition, was presented.

### **PUBLICATIONS:**

A paper, "Comparison of Edge Turbulence Imaging at Two Different Poloidal Locations in the Scrape-off Layer of Alcator C-Mod", by S. Zweben et al, was accepted for publication in Physics of Plasmas.

The paper, "Non-inductive plasma start-up on NSTX and projections to NSTX-U using transient CHI" by R Raman (U. Washington), et al., has now been published on-line [[Nuclear Fusion 53 \(2013\) 073017](#)]. The paper summarizes transient CHI experimental results from NSTX,

describes the CHI hardware enhancements to NSTX-U; which allows for much higher current generation potential in NSTX-U, and presents initial simulations of a full non-inductive start-up and non-inductive current ramp-up scenario for NSTX-U.

An article “Edge sheared flows and the dynamics of blob-filaments” by J. R. Myra (Lodestar Research) et al. has been published online in Nucl. Fusion 53 (2013) 073013, available at <http://stacks.iop.org/0029-5515/53/073013>. 2D time-resolved images from the NSTX gas puff imaging diagnostic and data from a synthetic diagnostic in numerical SOLT code simulations were analyzed using a new blob tracking algorithm (<http://nstx.pppl.gov/nstx/Software/Applications/BlobTracking.html>). Simulations reproduced many qualitative and quantitative features of the experimentally observed blob tracks. Mechanisms related to blob motion, SOL currents and radial inhomogeneity were shown to be sufficient to explain the presence or absence of mean and oscillating zonal sheared flows in selected shots in NSTX and Alcator C-Mod. The paper is based on Jim Myra’s 2012 IAEA presentation and invited talk at the 2012 APS-DPP meeting.

The following PPPL Reports were posted to the web:

PPPL-4880

Dependence of the L-H Transition on X-point Geometry and Divertor Recycling on NSTX

Authors: J.L. Battaglia et. al.

Submitted to: Nuclear Fusion (May 2013)

PPPL-4881

Generalized Courant-Snyder Theory for Charged Particle Dynamics in General Focusing Lattices

Authors: Hong Qin, Ronald C. Davidson, Moses Chung and Joshua W. Burby

Submitted to: Physical Review Letters (June 2013)

PPPL-4882

A Variational Multi-Symplectic PIC Algorithm with Smoothing Functions for the Vlasov-Maxwell System

Authors: J. Xiao, J. Liu, H. Qin and Z. Yu

Submitted to: Physics of Plasmas (June 2013)

PPPL-4883

First Observations of ELM Triggering by Injected Lithium Granules in EAST

Authors: D. Mansfield, et. al.

Submitted to: Physics of Plasmas (June 2013)

PPPL-4884

Liquid Lithium Divertor Characteristics and Plasma-Material Interactions in NSTX High-Performance Plasmas

Authors: Michael A. Jaworski, et. al.

Submitted to: Nuclear Fusion (June 2013)

PPPL-4885

Systems Analysis Exploration of Operating Points for the Korean Demo Program

Authors: C.E. Kessel, Keemin Kim, Jun Ho Yeom, T. Brown, P. Titus, G.H. Neilson

Presented at: Symposium on Fusion Engineering, San Francisco, CA (June 10-14, 2013)

PPPL-4886

Non-linear Modulation of Short Wavelength Compressional Alfvén Eigenmodes

Authors: E. Fredrickson, et. al.

Submitted to: Physics of Plasmas (December 2012)

### **LEADERSHIP POSITIONS:**

On June 3-5, N. Fisch served on the External Advisory Committee for the Naval Research Laboratory (NRL), reviewing the Plasma, Ionic Physics, and EM Railgun Program.

This report is also available on the following web site:

<http://www.pppl.gov/publication-type/weekly-highlights>