PRINCETON PLASMA PHYSICS LABORATORY

WEEKLY highlights

PPPL

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending August 9, 2013, are as follows:

NSTX (M. ONO):

J. Menard (PPPL), S. Sabbagh (Columbia University), and S. Kaye (PPPL) attended the U.S.-Korea conference on Science, Technology, and Entrepreneurship (UKC 2013) held in Secaucus, New Jersey on August 7-8 on behalf of NSTX/PPPL. S. Sabbagh gave a presentation entitled "Initial KSTAR Stability and Rotation Alteration Results for High Normalized Beta Plasmas Near or Exceeding the Ideal MHD No-wall Stability Limit", J. Menard gave a presentation entitled, "Research Plans and Collaboration Opportunities on NSTX-U", and Stan Kaye gave a presentation entitled " TRANSP Capabilities ".

On July 26, S. Sabbagh gave a presentation at the DIII-D Science Meeting titled “Resistive wall modes in high b_N, high q_{min} (DIII-D) target plasmas, and use of target in kinetic RWM experiment”. The talk examined the dynamics of RWMs in these low li plasmas in DIII-D with comparison to results from NSTX. The frequency and reproducibility of these modes in these plasmas makes them a good candidate for use in a proposed joint DIII-D/NSTX experiment investigating RWM stabilization physics.

Roger Raman (U-Washington) visited General Atomics during July 31-August 2, to participate in Massive Gas Injection experiments conducted on DIII-D. On August 1, an experiment was conducted (by Eric Hollmann, UCSD) in which a massive gas injection pulse was first injected from the bottom and then from the top (in separate experiments) in to a plasma discharge that was forced to undergo a downward moving VDE. The conditions were then reversed to cause the plasma to move upward. The goals were to study the effect of gas injection from different locations on the impact on halo currents and wall heat loading. On August 2, gas was injected from two MGI systems (that were separated in time) and was located at different toroidal locations to assess variations to the toroidal asymmetries in the radiated power (Nicolas Commaux, ORNL). Both these experiments relied on Neon injection and were highly successful in achieving their goals. An observation was that the DIII-D plasmas were highly reliable in being able to reproduce the reference discharge after the MGI pulse. A second observation was the reliability of the neutral beam system following the MGI pulse. Support and help from Nick Eidietis, John Wesley (General Atomics) and the DIII-D Disruption Mitigation group is much appreciated. The DIII-D experience will assist NSTX-U in planning its own first MGI experiments during FY15

Professor Wonho Choe of Korea Advanced Institute of Science and Technology (KAIST) visited NSTX-U/PPPL the week of August 5. He discussed x-rays diagnostics and related analysis codes with the NSTX-U/PPPL researchers. Future collaboration between NSTX-U and his group was

also discussed. He also met with the PPPL hall thruster researchers. Professor Choe gave a seminar entitled "Soft X-ray/VUV imaging diagnostics and impurity transport analysis on KSTAR."

Felipe Bedoya, a Purdue University graduate student, completed a two-month visit to PPPL last week. His activities focused on the installation and operation of the NSTX-U Materials Analysis and Particle Probe Upgrade (MAPP-U) on the Lithium Tokamak Experiment (LTX). This collaborative effort involved researchers from Purdue University, led by Professor Jean-Paul Allain (now at the University of Illinois at Urbana-Champaign), and PPPL. In situ analysis of samples exposed to LTX plasmas was performed using X-ray photoelectron spectroscopy (XPS). No difference in the XPS spectra was observed after exposure to plasmas in LTX either before or after its plasma-facing components (PFCs) were conditioned with lithium. This was not unexpected, since the LTX plasma currents and densities were still low. Argon glow discharge cleaning (GDC) was then performed to remove impurities on the LTX PFC surfaces. There were clear changes in the XPS spectra after the samples were exposure to the argon GDC, including a significant reduction in the carbon peak and signatures for iron that were not observed before. These measurements are the first of their kind in a tokamak, and provide a practical demonstration of MAPP-U for in situ analysis of the effects of plasmas on PFC surfaces.

The first of several Python (a linux OS-based scripting language that can be used for data manipulation and analysis) training courses was attended by close to 25 physicists on August 6. The training course covered the basics of Python variable and list operations, including floating point and character data types. Follow-up training on numpy, Python graphics and interfaces to MDS+ will be offered in several weeks. Development of expertise in Python is desired due to license pricing issues with commercially offered data manipulation products.

ITER & TOKAMAKS (R. WILSON):

DIII-D (R. Nazikian):

Implementation of predictive modeling tools for DIII-D discharges is being carried out by B. Grierson, with support form R. Budny, X. Yuan and R. Andre. Both transport and equilibrium solutions are being tested in an ITER baseline discharge with dominant electron heating. PTRANSP time-dependent simulations are being run over one second of the H-mode phase using the TGLF transport model; pedestal parameters are constrained using experimental measurements while core profiles are predicted. Predicted core electron density, ion temperature and toroidal rotation are in reasonable agreement with experimental measurements. Electron temperatures are predicted to be higher than experiment while toroidal rotation is somewhat lower than that measured by impurity charge-exchange spectroscopy. Equilibrium solutions are also being tested using neoclassical resistivity profiles from the NCLASS code, and prescribed sawtooth trigger times.

G. Taylor participated in DIII-D experiments as a co-session leader to study the effect of toroidal rotation on transport and accessibility to high performance operation in the ITER Baseline regime. When co NBI power was replaced with ECH power a significant increase in the turbulence level was observed on the BES signals, possibly explaining the reduced confinement

when electron heating is applied in the ITER Baseline regime. Data was also obtained from nearly balanced-NBI discharges with nearly 20 times less beam torque than in the co-NBI case.

ADVANCED PROJECTS (H. NEILSON):

In our collaboration on Japan's National Institute for Fusion Science (NIFS), N. Pablant reported progress made in his recent three-week working visit with the NIFS team. The purpose of the visit was to continue a transport study based on data from the U.S. x-ray imaging crystal spectrometer (XICS) on the Large Helical Device (LHD) stellarator and to make preparations for the 2013 LHD experimental campaign. Pablant and collaborators compared predictions from two theory-based neoclassical transport codes for a set of high electron-temperature LHD discharges, finding excellent agreement. The code results were also compared with the experimental transport results, providing insight into the role of neoclassical transport in these conditions. The analysis has been extended to several more time slices for these discharges, including the use of XICS profiles and equilibria calculated by the U.S. STELLOPT code. The transport properties before and after the transition to the high-temperature phase, and the effect of neutral beam injection on these plasmas is now being investigated. At the close of his visit, Pablant presented a NIFS seminar, "Investigation of ion and electron heat transport of high-Te ECH heated discharges in the Large Helical Device," reporting the status of research which be presented in an oral talk at the International Stellarator Heliotron Workshop in September. In addition, XICS alignment, calibration, and installation tasks were completed, fully preparing the system for the start of the 2013 campaign.

Our supplier, Applied Power Systems (APS) of Hicksville, New York, completed acceptance testing on the fourth of five trim coil power supply units for the Wendelstein 7-X stellarator at Germany's Max Planck Institute for Plasma Physics.

THEORY (A. BHATTACHARJEE):

Please see publications and invited talks

COMPUTATIONAL PLASMA PHYSICS GROUP (S. JARDIN):

E. Feibush presented "Python Programming at PPPL" to NSTX physicists on August 6. This introductory workshop included hands-on programming exercises that emphasized the elements and features of Python. Aspects of object-oriented programming were included. Course materials were posted on-line for future reference. Subsequent presentations will cover numerical python and the programming interface to MDSplus. Science Education interns Jared Miller, Michael Knyszek, and Matthew Lotocki served as Teaching Assistants for the workshop.

ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):

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

Planning efforts are underway for the October Lehman review.

Construction: In-vessel welding of the Bay JK stiffeners and the S-Flip port continues. The tFIDA installation will begin next week. Work continues on the alignment and prep of the TF outer support structure. Welding of the splice plates will begin next week.

CS Upgrade: The Centerstack turning fixture was received at PPPL. The backing plates for the CS tiles were received from Zenex. The first OH braze joint sample successfully completed 400,000 full load test cycles in the MTS tensile test machine. Three more test sample are scheduled for testing. A series of tensile tests were performed on Nicrobazed and e-beam welded CuCrZr test samples. The electron beam welded samples provided the best performance on CuCrZr. The process has been selected for the remanufacture of the PCHERS passive plates and the TF Lead Extensions.

The interference between the TF vertical buss and the Pedestal Supports has been cleared. The TF vertical run has been re-designed and the model was provided for analysis. A Parasolid model was provided for analysis to verify the strength of the PF1 Flag Joints. A Tech Shop work request was submitted to fabricate the CHI Rings, OH Co-Axial Connector and busbar Supports.

Digital Coil Protection System (DCPS): A successful FDR for the DCPS software design and a "pencils down" review of the remaining DCPS tasks was held on Thursday.

NBI Upgrade: Welding and leak checking of LHe line in the TTC continued. TTC HVAC problems have been resolved. Fabrication and leak checking of LHe and LN cryo line continues in the NB shop. The DI water system subcontract continues with pipe fitting, welding, and installations in the Pump Room and the MER. The Ion Source and Ion Dump DI H2O Pump requisition was approved and the procurement process started. The power system cable and tray procurement process is in progress. A pre-bid conference and tour was held for bidders. The cable tray support structure order is in progress. Final work is being performed on rectangular duct shields prior to leak checking. The JK VV reinforcements and SFLIP pieces have been prepared and installation on the VV is in progress. NB Armor tiles are ready for bakeout so oven time will be arranged. Management and CAMs performed a monthly status for EVMS.

OFFICE OF COMMUNICATIONS: (K. MACPHERSON):

K. MacPherson participated in two DOE teleconferences on August 6 and August 9 on a strategic communications plan for the National Labs that includes a new website focused on the National Labs. She also was nominated to serve as a judge in the CASE (Council for the Advancement and Support of Education) Accolades program and attended an informational meeting on August 5.

DIRECTOR'S OFFICE (C. AUSTIN):

On August 1 - 2, M. Zarnstorff attended the meeting of the Chief Research Officers of the DOE National Laboratories.

On August 6 - 7, S. Prager, R. Hawryluk, J. Menard, H. Neilson, and M. Zarnstorff attended a program planning discussion at Massachusetts Institute of Technology.

On August 7, M. Zarnstorff attended the US-Korea Conference on Science, Technology, and Entrepreneurship.

On August 2, Professor Anne White, Massachusetts Institute of Technology presented a colloquium entitled, "A New Correlation ECE Diagnostic for C-Mod and Progress on Transport Model Validation".

INVITED TALKS:

W. Wang participated the Festival de Theorie on "Reduced models of complex plasma dynamics" (Aix-en-Provence, France, July 8-26) and presented an invited talk entitled "Fluctuation Driven Plasma Current, Poloidal Rotation and Flow Structure".

PUBLICATIONS:

A paper on "Properties of Alfvén eigenmodes in the TAE range on the National Spherical Torus Experiment-Upgrade" by M. Podestà (PPPL) et al. has been published online in Physics of Plasmas 20, 0825012 (2013), (http://pop.aip.org/resource/1/phpaen/v20/i8/p082502_s1). The paper reports on predictions of modes in the TAE range of frequency for NSTX-U scenarios with different NB injection geometry. In particular, the stability of *AEs as the new NB sources are used is investigated. Analysis is performed through the ideal MHD code NOVA-K. Results show that, for the scenarios considered in this work, modifications of the Alfvén continuum result in a frequency up-shift and a broadening of the radial mode structure. The latter effect may have consequences for fast ion transport by TAEs in NSTX-U. Stability calculations through NOVA-K including finite plasma rotation indicate that TAEs are potentially unstable for the more tangential NBI scenarios, with ion Landau damping representing the dominant damping mechanism. [NSTX]

The article "Electron temperature profile reconstructions from multi-energy SXR measurements using neural networks" by D.J. Clayton (NSTec/JHU) et al. was published in Plasma Phys. Control. Fusion 55, 095015 (Sept. 2013). The article describes the implementation of neural networks to reconstruct electron temperature profiles from multi-energy soft-x-ray (ME-SXR) arrays and other plasma diagnostics with fast time resolution. By training a neural network to match fast (>10 kHz) x-ray data with Te profiles from the 60 Hz Thomson scattering system, the ME-SXR diagnostic can be used to produce Te profiles with high time resolution. In particular, a new ME-SXR system will be used in conjunction with impurity injection to measure cold pulse propagation in NSTX-U plasmas for direct, perturbative heat transport measurements. Synthetic ME-SXR data were used to optimize performance of the neural networks and study the

impact of including data from various diagnostics in the networks. Initial tests on data from previous ME-SXR diagnostics on NSTX have proven successful. [NSTX]

A paper titled "Linear Stability and Nonlinear Dynamics of the Fishbone Mode in Spherical Tokamaks" by F. Wang, G. Fu, J. Breslau, and J. Liu has been submitted to Physical Review Letters. This paper reports the recent work done in collaboration with Feng Wang, a graduate student from Dalian University of Technology, Dalian, China. The abstract reads: "Extensive linear and nonlinear simulations have been carried out to investigate the energetic particle-driven fishbone instability in spherical tokamak plasmas with weakly reversed q profi le and the minimum of q slightly above unity. The global kinetic-MHD hybrid code M3D-K is used. Numerical results show that a fishbone instability is excited by energetic beam ions preferentially at higher q_min values, consistent with the observed appearance of the fishbone before the "long-lived mode" in MAST and NSTX experiments. In contrast, at lower q_min values, the fi shbone tends to be stable. In this case, the beam ion effects are strongly stabilizing for the non-resonant kink mode. Nonlinear simulations show that the fishbone saturates with strong downward frequency chirping as well as radial flattening of the beam ion distribution. An (m,n)=(2,1) magnetic island is found to be driven nonlinearly by the fi shbone instability, which could provide a trigger for the (2,1) neoclassical tearing mode sometime observed after the fishbone instability in NSTX." [Theory]

The following reports were posted on the web:

Liquid Metal Plasma-Facing Component Research On the National Spherical Torus Experiment PPPL-4936
Authors: Michael A. Jaworski, A. Khodak, R. Kaita
Submitted to: Plasma Physics and Controlled Fusion (July 2013) Presented at: 40th EPS, Expo, Finland (July 20113)

Gyrokinetic Particle Simulation Of Nonlinear Evolution Of Mirror Instability PPPL-4937
Authors: Peter Porazik and Jay R. Johnson
Submitted to: Journal of Geophysical Research (July 2013)

Linear Dispersion Relation For The Mirror Instability In Context Of The Gyrokinetic Theory PPPL-4938
Authors: Peter Porazik and Jay Johnson
Submitted to: Physics of Plasmas (July 2013)

Some Unsolved Challenges in RF Heating and Current Drive PPPL-4939
Authors: Nathaniel J. Fisch
Submitted to: Fusion Science and Technology (April 2013)

Methods of RF Current Drive PPPL-4940
Authors: Nathaniel J. Fisch
Submitted to: Fusion Science and Technology (April 2013)

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