PRINCETON PLASMA PHYSICS LABORATORY
WEEKLY highlights

PPPL
U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending August 23, 2013, are as follows:

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

Subcontract Proposal Review Board (SPEB) kickoff meetings were held to develop Requests for Proposals (RFPs) prior to DOE Review for design support for the ITER Electron Cyclotron Emission (ECE) and Toroidal Interferometer/Polarimeter (TIP) diagnostics. Final modifications to the Statements of Work were requested from the board members.

Meetings were held between ECE experts from the US, India, and the ITER Organization to discuss a proposal from India for the design of the polarization splitter boxes and transmission lines in the interspace and port cell regions of equatorial port 9.

US expert feedback was requested for a proposed design for the ECE windows, presented by a contractor working for the ITER organization.

NSTX (M. ONO):

Three physicists, Ron Parker, Greg Wallace and Syun'ichi Shiraiwa from MIT visited PPPL on August 19 to discuss collaboration opportunities on the development of an ECH system, and associated physics modeling and diagnostics, for NSTX-U. The PPPL participants included B. Ellis, E. Fredd, S. Gerhardt, N. Greenough, J. Hosea, J. Menard, M. Ono, C. Phillips, G. Taylor and E. Valeo. Presentations were made on the overall system by N. Greenough, the MIT HV power supply by Greg Wallace, on ECH/EBW scenarios and modeling by G. Taylor, and on collaboration opportunities for MIT by Ron Parker. The meeting was very informative and there were several areas which can benefit from collaboration between MIT and PPPL including: 1) system development and design, 2) power supply system, 3) launcher development and design, 4) modeling and scenario development, and (5) diagnostics. We are looking forward to this collaboration and will work together to clearly define work scopes and to integrate them between PPPL and MIT.

W. Guttenfelder (PPPL) visited MAST (August 12-20) to lead an experiment on momentum transport using resonant magnetic field perturbations (RMP) to alter toroidal rotation. The experiment (part of ITPA task TC-15) was operationally successful, with small but observable toroidal rotation perturbations occurring coincident with application of short RMP coil current pulses in both H-mode (using n=4) and L-mode (using n=3). The decay of the perturbations upon RMP turn-off will be used in an attempt to infer momentum diffusivity and convection, similar to analysis performed for NSTX H-modes by W. Solomon and S. Kaye. Additional run time may

be given to attempt NBI modulation experiments to provide further constraint on the inferred momentum transport.

This week (August 19 - 23) N. Bertelli (PPPL) visited ORNL to collaborate with E. F. Jaeger (ORNL). The purpose of his visit to ORNL is to work with Fred on the full wave code AORSA in order to try to understand the RF edge losses in NSTX from the modeling point of view including a proxy artificial damping such as collisional damping. The magnitude of the edge collisional losses are being evaluated as a function of the antenna phases (or the toroidal mode numbers) and the minimum density in front of the antenna. Moreover, the magnitude of the edge collisional losses can be used to evaluate possible potential damping mechanisms in the SOL. Several runs with a single dominant mode have been performed and analyzed with Fred. In addition, 3D Aorsa runs have been performed in order to reconstruct the full antenna spectrum. Finally, several useful and productive discusses about this work has been held with the ORNL RF researchers including Lee Berry, David Green, and Phil Ryan.

Preparations for plasma operations in the NSTX-U configuration also continued with the ongoing maintenance of the power supply and distribution equipment for the neutral beams. The retro-fitting of the new firing generators in their final positions in the field coil power conversion (FCPC) system rectifiers continues.

ITER & TOKAMAKS (R. WILSON):

DIII-D (R. Nazikian):

Matt Kriete of Virginia Tech completed a nine week visit to DIII-D to work with B. Tobias under the NUF program and has produced a report on his experience with the Mm-wave Imaging Reflectometer (MIR). Matt provided valuable assistance during installation and testing of this new diagnostic.

B. Grierson led an experiment with Lothar Schmitz (UCLA) to investigate the L-H transition and main-ion rotation in helium plasmas. Helium plasmas with deuterium neutral beams allow for high resolution main-ion toroidal and poloidal flow measurements during the L-H transition. The evolution of the flows and pedestal pressure gradient, Reynolds stress from plunging probes, and turbulence characteristics during the L-H transition are being analyzed.

The gyrotron 8 water manifold is on course for delivery at the end of August. The water manifold temperature sensors were ordered for shipment to the vendor. It is expected that the manifold will be installed in the September/October time frame.

Alcator C-Mod (R. Ellis):

A first-principles model for the uncertainty in polarization angle measured by a photo-elastic modulator (PEM)-based polarimeter has been validated quantitatively. The model computes the time-dependent electric current generated by an avalanche photodiode (APD) that is illuminated by linearly polarized light after passing through two PEMs and a linear polarizer. The signal amplitude is randomly perturbed according to Poisson statistics. For an ideal APD with zero dark current, the numerical model confirms the analytic expectation that the measurement uncertainty

should scale as 1/(I_inc) ^0.5 where I_inc is the incident light intensity. When the APD's dark current is added to the model, along with its own Poisson statistical variation, the model predicts that the polarization-angle uncertainty should scale as 1/(I_inc)^0.9. This behavior was confirmed experimentally by measuring the polarization angle (and its variability) of linearly polarized light by the in-situ C-Mod Motional Stark Effect polarimeter as the light intensity was varied over ~2 orders of magnitude during a C-Mod maintenance period. The magnitude of the measured variability agrees with the model prediction to ~20%. This work highlights the importance of using photodetectors with low dark current in MSE diagnostics.

KSTAR (J. R. Wilson):

D. Mueller and J.K. Park travelled to KSTAR to participate in experiments during August. Mueller continued his work with the controls group in improving the performance of the KSTAR control system to achieve enhanced shape control, vertical position control, H-mode control and long pulse steady state operation. Progress was made in all these areas by finding better settings for the feedback gains, improved cancelation of cross couplings and use of voltage difference signals. H-mode discharges with kappa > 2 for > 1s were achieved with only small vertical drift. J.K. Park continued his experiments from last year on n=1 error fields and RMP ELM suppression. Studies of the density threshold for locked modes were performed. One result was to find that the error field on KSTAR is very axisymmetric.

ADVANCED PROJECTS (H. NEILSON):

Acceptance Testing on the fifth and final W7-X Trim Coil Power Supply Unit (PSU) has been successfully completed. A Shipping Release has been approved by PPPL for the shipment of all five (5) PSUs to Germany. The vendor, Applied Power Systems, is preparing the PSUs for shipment, which is expected by weeks end.

THEORY (A. BHATTACHARJEE):

Gyrokinetic simulations with the GTS code have been employed to investigate the bootstrap current generation in the presence of drift wave turbulence. Plasma self-generated non-inductive currents in fusion devices, e.g, the bootstrap current, have a great impact on overall plasma confinement and, specifically, on key MHD instabilities such as neoclassical tearing mode (NTM) and edge localized mode (ELM). The collisionless trapped electron mode (CTEM) is found to induce a significant, quasi-stationary parallel current. Recent nonlinear GTS simulations, which include both turbulent and neoclassical physics self-consistently and simultaneously, show that bootstrap current generation is significantly enhanced in the presence of CTEM-induced fluctuations. This is consistent with earlier GTS results of CTEM turbulence simulations without neoclassical physics. The total bootstrap current, however, is not a simple addition of turbulence-induced current to the neoclassical bootstrap current. The underlying dynamics is closely related to the nonlinear plasma flow generation by turbulent fluctuations. However, unlike toroidal momentum, which is mostly carried by ions, the turbulent current is mainly carried by electrons and driven by electron residual stress with possible contribution due to turbulent acceleration. The fluctuation-induced current generation exhibits a similar characteristic dependence on plasma parameters as that of neoclassical bootstrap current, but

with different physical origins. Specifically, it increases with the pressure gradient, decreases with poloidal magnetic field (and equilibrium current Ip), and increases with the radial variation of the safety factor. Interestingly, the CTEM driven current is essentially carried by trapped electrons, unlike the neoclassical bootstrap current which is mainly carried by passing particles. The work is carried out by W. X. Wang, S. Ethier and their collaborators.

This week's theory seminar was presented by Professor Alain Brizard from Saint Michael's College. Alain is a graduate of PPPL with extensive experience in gyrokinetic theory, is the author of "Introduction to Lagrangian Mechanics" and co-author of "Ray tracing & beyond: phase space methods in plasma wave theory" books. He presented the effect of guiding-center polarization on momentum conservation properties. Gyrokinetic simulations might show momentum conservation without the guiding-center polarization terms, however he showed that these terms should be included to be more realistic. It was argued that in the long wavelength limit, the guiding-center and gyro-center polarizations have the same orders, and are second order effects. In the talk momentum conservation laws for the truncated gyrokinetic Vlasov-Poisson equations in axisymmetric tokamak geometry are derived by the Noether method. The talk emphasized the role played by the guiding-center polarization as well as other higher-order guiding-center effects. A discussion on the relation between Littlejohn's 1983 derivation of the guiding-center transformation and the guiding-center transformation was also given.

COMPUTATIONAL PLASMA PHYSICS GROUP (S. JARDIN):

E. Feibush conducted a second hands-on programming workshop about scientific computing in Python tailored for PPPL. The presentation was given to NSTX physicists on August 20 and focused on Python's N-dimensional array software "numpy". Topics and programming exercises included the creation and use of computationally efficient arrays, using Python to access shot data stored in MDSplus, and introduced plotting data from Python. Science Education interns Jared Miller, Michael Knyszek, and Matthew Lotocki served as Teaching Assistants for the workshop. Knyszek has also completed a Python application programming interface to enable sending numpy arrays to ElVis for animating f(x,t) and f(x,y,t) data. Course materials are available on the web at http://w3.pppl.gov/~efeibush/python.

ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):

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

Construction: The in-vessel welding of the JK reinforcements and the S-Flip port continues. The installation of the upper outer TF support ring continues with the machining of the splice plates. Welding of these splice plates has just been started. Holes are being drilled in the PF5 clamp at bay L to accommodate the new design and the welding of studs to the other PF5 clamps continues. Bakeout tubing is being installed on the JK nozzle. TF flags are being re-silverplated in the upper and lower umbrellas. The new tFIDA tube has been rough machined and annealed. The bay L port has been vacuum prepped and is ready for installation. The electricians are pre-fabricating category 3 cables.

CS Upgrade: The four quadrants have been married together and lifted into the taping station in preparation of the ground wrap installation. The OH Winding station has been completed and transported over to C-site MG in preparation of testing. A teleconference was held with Everson to discuss the fabrication of the first set of mandrels with the newly selected subtler supplier. Use of flux core welding was approved in place of the TIG welding currently on the drawing as an improvement over distortion and permeability of the finished product. A drawing change will be issued by PPPL to cover the change. The last shipment of conductors was received at PPPL on Thursday completing the contract with Major Tool. Four sets of OH braze samples were successfully cycled to over 300k cycles in the material test lab completing the cyclic test portion of the tests. A successful review of the buss bar analysis was conducted. The CHI, OH and PF1 Bus Bar designs have been approved by the analysis group. A minor design change is being made to the TF Bus Bar design and a final iteration will be performed to conclude the analysis. The design is now ready for Final Design Review. The copper bussbar material that was ordered has been received at the warehouse and it is now being inspected.

NBI Upgrade: Welding and leakchecking of LHe line in the NTC continues. The nitrogen system is almost complete with one weld remaining. The DI water system subcontract continues with pipe prep and fitting, welding, and installations in the Pump Room and the MER. The piping installation in the Pump Room is complete. The Ion Source and Ion Dump DI H2O Pump procurement process continues. Vacuum system installation detailed drawings are in progress. The power system cable and tray procurement process is in progress. The cable tray support structure order is expected early next month. Evaluation and revision of forecast dates for NBI controls took place this week. The JK VV reinforcements and SFLIP piece installation on the VV continues. Management participated in the monthly IPT meeting.

OFFICE OF COMMUNICATIONS: (K. MACPHERSON):

K. MacPherson was named a member of the APS-DPP Public Information Committee.

PUBLICATIONS:

The paper "Progress in simulating turbulent electron thermal transport in NSTX" by W. Guttenfelder (PPPL) et al. was published in Nuclear Fusion 53, 093022 (2013) (http://iopscience.iop.org/0029-5515/53/9/093022). The paper summarizes the progress in running electromagnetic nonlinear gyrokinetic turbulence simulations based on realistic equililbrium and measured profiles from NSTX. Different microinstabilites are predicted to be unstable depending on experimental parameters. In particular, results were shown from microtearing turbulence (at high beta and high collisionality), electron temperature gradient (ETG) turbulence (at low beta), and kinetic ballooning mode (KBM) turbulence (at high beta and low collisionality). Numerical challenges associated with the simulations are discussed, as well as predictions of transport and scaling with parameters (such as collisionality) that may be used to distinguish the mechanisms experimentally. *(NSTX)*

"The Use of DC Glow Discharges as Undergraduate Educational Tools" was published in the August 19 edition of the American Journal of Physics (Vol. 81, Issue 9). In it, authors S. Wissel, A. Zwicker, J. Ross, and S. Gershman describe how plasmas have a beguiling way of getting

students interested in physics. They argue that plasmas can and should be incorporated into the undergraduate curriculum as both demonstrations and advanced investigations of electromagnetism and quantum effects. The article describes a device, based on a direct-current (dc) glow discharge tube, which allows for a number of experiments into topics such as electrical breakdown, spectroscopy, magnetism, and electron temperature. In addition, a photograph from the article showing several of the plasma sources built for this work was chosen as the cover art for the issue. *(Science Education)*

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