PRINCETON PLASMA PHYSICS LABORATORY
WEEKLY highlights

PPPL
U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending February 19, 2016 are as follows:

U.S. ITER FABRICATION (C. NEUMEYER):

Steady State Electric Network (SSEN):

The plan for the final three SSEN procurements—Uninterruptible Power Supply (UPS) system, DC Distribution, and Low Voltage (LV) Distribution and Sub-distribution Panels—was presented to the U.S. ITER Project Manager at ORNL who endorsed it in principle. After a description of the Corrective Action Plan (CAP) underway at PPPL, the U.S. ITER Procurement Manager endorsed the continued use of PPPL Procurement for the remaining procurement actions. A Project Change Request has been submitted, the purchasing specifications are in the review pipeline, and Requests for Proposal (RFPs) will be issued in March.

The contract amendment for the 6.6kV switchgear procurement with Schneider Electric was signed, taking into account the changes that were necessitated by alterations to the Tokamak Cooling Water System (TCWS).

Diagnostics:

Low Field Side Reflectometer (LFSR): The LFSR High Frequency Instrument Report was issued by GA/UCLA. The design report lays out the approach to be taken to upgrade the wide band millimeter source developed for ITER LFSR through an SBIR grant from DOE, into a FMCW instrument for testing on the LFSR transmission line test stand in GA.

The Gaussian telescope concept of quasi-optical parallel imaging concave mirrors was tested successfully on the GA transmission line test stand at 110 GHz. Insertion loss of the telescope was measured to be less than five percent. A real-size aluminum prototype is planned to test the passive self-aligning features.

Motional Stark Effect (MSE): A method has been developed to fix the MSE model conversion difficulties. Initially, the models supplied by NOVA to PPPL would not be in the appropriate coordinate system, but this has been fixed and the conversion is appropriate. Because of this, the MSE ray trace models have been realigned and then moved up 120mm to incorporate the tab exclusion zone. Analysis is being done at this new location to get the appropriate diagnostic path and to optimize the mirrors.

Diagnostic RGA (DRGA): Draft fabrication drawings were generated for the sampling pipe that will be used to connect the heated sampling aperture currently in fabrication to the existing proto-DRGA analysis chamber. When assembled, this system will be functionally prototypic to the LP12 RGA system and will allow measurements of conductance and sampling performance.

Upper Port 11 and 14 Integration and DSM Engineering: The Upper Port engineering team has put together a concept design of ISS mounted Bioshield. This concept would work for both US EQ and UP port. In this concept, human access is not required in the ISS side to remove the port cell as all of the disconnect between ISS and PCS happens on port cell side of Bioshield. The next step is to "market" this design idea to the IO and other DA stakeholders. Once this design is accepted the team can move ahead with mechanical design and neutronics analysis of the bio-shield.

NSTX-U (M. ONO):

FY 2016 NSTX-U plasma operations update: The department has completed 3.14 run weeks and 314 plasma shots. The total operation targets are to be decided.

An article on optimization work for the NSTX-U non-axisymmetric control coils (NCC) has been highlighted recently in an IOP LabTalk article, http://iopscience.iop.org/0741-3335/labtalk-article/63548. The work focused on coupling stellarator optimization tools (STELLOPT) to the ideal perturbed equilibrium code (IPEC) and the neoclassical toroidal viscosity code (PENT). The resulting code (IPECOPT) was applied to NSTX-U equilibria, exploring the possibility of core versus edge rotation control with 3D fields. The planned NCC set was evaluated and found capable to drive both core and edge torques through independent field perturbations. This work was a collaboration between researchers at PPPL (S. Lazerson, J-K. Park, N. Logan) and Columbia University (A. Boozer).

D. Ogata, a graduate student of Professor David Newman of the University of Alaska, finished a three month visit to NSTX-U as part of the Department of Energy (DOE) Office of Science Graduate Student Research (SCGSR) Program. His project was "Characterizing edge transport with gas puff imaging," working primarily with S. Zweben (PPPL). He analyzed GPI data from 2010 and derived an estimate for the local spatial spreading of plasma blobs, showing that this was consistent with a diffusion process at ~1 m2/second. This will be part of his PhD thesis, and will be written up for publication.

R. La Haye of General Atomics DIII-D traveled to the Princeton Plasma Physics Laboratory for the second week of February to initiate the tearing stability experimental collaboration on NSTX-U. High beta discharges from the first startup run in H-mode showed the characteristic signature of a neoclassical tearing mode in that the n=1 Mirnov amplitude decreased linearly as the square of betap goes down. Two XPs were written with the first (XP1544 "Make contact with NSTX for n=1 tearing stability") distributed for comments and to tentatively be run in early Spring of this year.

On February 11, W. Guttenfelder (PPPL) presented a talk at the UCLA Department of Physics and Astronomy titled "Progress, challenges and plans in transport research in NSTX-Upgrade" as part of the NSTX-U Outreach Seminar series. During the visit, collaborative discussions were

held with Professor Jenko's group on NSTX-U simulation opportunities using the GENE code, and with the UCLA diagnostic group on NSTX-U data analysis.

On February 15, six shots were taken towards XMP-137 (Increase Ip and Elongation in L- and H-Mode). The start of flattop was moved earlier and the evolution of heating, elongation and fueling in the rampup to 800 kA were adjusted to make progress toward diverting during periods of lower internal inductance.

On February 16 and February 18, a combined eight shots were taken towards XP-1506 (Low-beta, low-density locked mode studies). All but one of the eight shots were dedicated to developing long (~1 sec), low-density, 600 kA, ohmic discharges using a 20 kA ohmic pre-charge. This effort was successful in producing a good target for the planned n=1 compass scan. As such, n=1 fields were applied during the final discharge on February 18, and good evidence of field penetration was observed. These experiments will be continued in the following weeks.

Twenty-five shots were completed on February 19 towards XMP-115 (ISOFLUX Commissioning). These shots were successful to implement control of the inner wall limited algorithm in isoflux control and achieved a stable plasma elongation of kappa ~ 1.8 at li ~ 1.2 by tuning the vertical control gains. This represents an improvement in kappa of about 0.1 at high li. Also the first shots using the double null ISOFLUX algorithm were made successfully, but gains must be tuned before this algorithm is ready for generic experiments. Overall, it was a very successful day qualifying the control system.

NSTX-U plasma operations continued this past week with experiments to further investigate the use of ISOFLUX and rtEFIT control via the Plasma Control System and the outer PF coils. Progress was also made on experiments on H-mode access and on optimizing plasma current/elongation at the higher available Neutral Beam power. We have been able to tune systems for some of our longest L-mode plasma shots. Four of the six neutral beam ion sources are currently operational. The ion source in the NB1A position has a vacuum leak and will be replaced with a fresh spare next week. The autotransformer in the NB2B power system will be replaced with a spare unit during the next maintenance period. Also this week, work continued on the development of tools and procedures for the recovery of in-vessel debris from the BES shutter covers. MAPP samples were successfully obtained and are being analyzed. The final design of the power systems for the Massive Gas Injector system was successfully reviewed. A vacuum vessel boronization will be performed on Sunday.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

The first TRANSP analysis of DIII-D discharges with deuterium main-ion CER measurements have been successfully completed and used to determine the diffusive momentum transport coefficients of the main ions. In the H-mode, the impurity toroidal velocity can be non-monotonic in the steep gradient region even in the presence of large beam torques, and this would indicate a negative effective momentum diffusivity. However, the main-ion toroidal rotation is monotonically decreasing in these plasmas, indicating that the inference of negative diffusivity is an artifact of the impurity measurement. The consequences of using impurity versus

main-ion rotation for experimental momentum transport and model validation will be presented at the 2016 Transport Task Force (TTF) by S. Haskey, who has implemented main-ion CER in the OMFIT workflow.

N. Logan gave a live demonstration of the new OMFIT profiles tool at General Atomics, following on the heels of a very well received Friday Science Meeting presentation of the same tool. The tool's development was motivated by the need to fit kinetic profiles in tokamak plasmas in a robust and generalized manner, reducing the amount of human interaction while maintaining quality of information. The development effort has been lead by N. C. Logan, B. A. Grierson, and S. R. Haskey from PPPL, D. Eldon from Princeton University, and O. Meneghini, and S. P. Smith from General Atomics. The work has relied heavily on the expertise of many others who have seen the pressing need for a unified tool enabling the visualization of plasma dynamics as well as accurate quantitative analysis of fundamental plasma parameters. The live demo had over 40 people in attendance as well as roughly 20 connected remotely, including members of the DOE.

The Super Supply Patch Panel construction is in progress under the leadership of A. Nagy. The patch panel is aimed at incorporating the ASIPP power supplies into the existing DIII-D power supplies required to operate DIII-D. The patch panel will allow for the integration of these fast switching bipolar power supplies with all machine coils except for the ohmic heating and toroidal field coils.

ADVANCED PROJECTS (H. NEILSON):

D. Gates, N. Pablant, H. Neilson, and several other PPPL scientists attended a workshop on stellarator research needs, held February 16-17 at the MIT Plasma Science and Fusion Center. Participants representing ten U.S. research institutions considered the research needs and scientific opportunities for the development of a revitalized U.S. stellarator program. Gates co-chaired the workshop together with Professor David Anderson of the University of Wisconsin. Neilson led a discussion on the opportunities to address research needs using overseas experiments, namely Wendelstein 7-X (W7-X) and the Large Helical Device (LHD).

The Laboratory is leading the fabrication of two TDU Scraper Elements for W7-X, in collaboration with Oak Ridge National Laboratory and Germany's Max Planck Institute for Plasma Physics (IPP). Each scraper consists of two subassemblies, which will be supplied by commercial fabricators using material furnished by the project, with final assembly to be performed by PPPL. A contract was awarded to Imperial Machine & Tool Co. of Columbia, New Jersey, for fabrication of one of the subassemblies, namely the base plate. For the other subassembly, the first wall, requests for quotation (RFQ) to fabricate the metallic and graphite parts were recently issued. It is expected that contract awards for these tasks will be made in the next few days.

THEORY (A. BHATTACHARJEE):

M. Parsons visited the Joint European Torus (JET) from February 5-17 to discuss details of an existing machine-learning-based disruption predictor and to identify ways to improve the predictor's accuracy and portability to other machines. The software that Parsons has developed and benchmarked against JET's predictor, as part of an LDRD project with W. Tang and E. Feibush, will soon be applied to old NSTX data to use as a baseline for further development of the predictor. This PPPL-JET collaboration is strongly supported by the JET management, which is especially interested in improving their disruption avoidance capabilities before any future DT campaigns.

On February 18, Scott Baalrud (University of Iowa) presented a theory seminar on Theory for Transport Properties of Warm Dense Matter: "Progress in a number of research frontiers relies upon an accurate description of the transport coefficients of warm and hot dense matter, characterized by densities near those of solids and temperatures ranging from several to hundreds of eV. Examples include inertial confinement fusion, evolution of giant planets, exoplanets, and other compact astrophysical objects such as white dwarf stars, as well as numerous high energy density laboratory experiments. These conditions are too dense for standard plasma theories to apply and too hot for condensed matter theories to apply. The challenge is to account for the combined effects of strong Coulomb coupling of ions and quantum degeneracy of electrons. This seminar will discuss the first theory to provide fast and accurate predictions of ionic transport coefficients in this regime. The approach combines two recent developments. One is the effective potential theory (EPT), which is a physically motivated approach to extend plasma kinetic theory into the strong coupling regime. The second is a new average atom model, which provides accurate radial density distributions at high-density conditions, accounting for effects such as pressure ionization. Results are compared with state-of-the-art orbital-free density functional theory computations, revealing that the theory is accurate from high temperature through the warm dense matter regime, breaking down when the system exhibits liquid-like behaviors. A number of properties are considered, including diffusion, viscosity and thermal conductivity."

W. Fox presented an Invited Talk at the 2016 NNSA Stewardship Science Academic Partnership Symposium. The talk was entitled "Dynamics of Magnetic Reconnection In High Energy Density Plasmas," and focused on recent results from a series of experiments on magnetic reconnection between colliding magnetized plasmas. The talk was conducted on the OMEGA EP facility at the University of Rochester through a grant from the NNSA (Principal Investigator: A. Bhattacharjee).

A paper entitled "Dynamics of ion temperature gradient turbulence and transport with a static magnetic island," by O. Izacard (LLNL, assigned at PPPL), C. Holland (UCSD), S. D. James (University of Tulsa), and D. P. Brennan (PPPL) was published in Physics of Plasmas 23, 022304 (2016); http://dx.doi.org/10.1063/1.4941704. This work shows numerical simulations via a slab 2D 5-field fluid model in BOUT++ of the effects of a static magnetic island on ITG transport and turbulence and a qualitative feedback of the modified ITG on the tearing mode. Particularly, a threshold size of the island width must be exceeded to significantly impact the turbulence dynamic, and a poloidal asymmetry of the ion radial heat transport is observed inside the island. This study sets the stage for future comparisons with observed asymmetries in experiments and PIC or gyrokinetic codes.

PLASMA SCIENCE & TECHNOLOGY (P. EFTHIMION):

This week, Sergey Averkin from Worcester Polytechnic Institute presented a Plasma Science and Technology seminar on Simplified Fluid and Kinetic Simulation Algorithms in Non-equilibrium Plasma Simulations: Advanced Global Model and Unstructured 3D PIC-DSMC Method.

The abstract reads: "Modeling and simulation of non-equilibrium chemically reacting plasmas is a challenging problem owing to the presence of complicated plasma chemistry and coupling between volume, surface, and transport non-equilibrium processes. Two different approaches are presented and discussed in detail. The first part of the talk outlines a Global Enhanced Vibrational Kinetic Model (GEVKM) and its application to the simulation of an RF discharge chamber of a new High Current Negative Hydrogen Ion Source developed by Busek Co. Inc. and WPI. The space-averaged steady-state continuity equations coupled with the electron energy equation, the total energy equation and heat transfer to the chamber walls, are solved simultaneously in order to obtain the space-averaged number densities of the plasma components, the electron, heavy particle and wall temperatures. The GEVKM is supplemented by a comprehensive set of surface and volumetric chemical processes (22 species and more than 1000 chemical reactions) governing vibrational and ionization kinetics of hydrogen plasmas. The model is computationally efficient and is used in parametric studies with thousands of points in parameter space. The second part of the talk outlines new developments in the Particle-in-Cell and Direct Simulation Monte Carlo methods (U3DPIC-DSMC) on unstructured 3D meshes used to model the Wang Chang-Uhlenbeck equation coupled with the Poisson equation. These developments include: a new finite volume algorithm for the electric field evaluation on arbitrary unstructured tetrahedral grids, based on the Multi-Point Flux Approximation (MPFA) method with a parallel GMRES solver with ILU(0) preconditioner; an improved implementation of the algorithms for gathering and scattering on unstructured meshes; a new particle tracing algorithm and a kinetic 5-moment boundary condition method for inlets\outlets based on the characteristics of 5-moment (Euler) equations. The U3DPIC-DSMC method can provide detailed information of the distribution functions of plasma components in complicated geometries."

BEST PRACTICES & OUTREACH (J. DELOOPER):

Science Education (A. Zwicker):

Princeton Plasma Physics Laboratory hosted the DOE Middle and High School Science Bowls on February 19 and 20.

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