Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending May 5, 2017 are as follows:

U.S. ITER FABRICATION (H. NEILSON):

Steady State Electrical Network (J. Dellas):

The Laboratory continues to make progress toward completion of U.S. equipment deliveries for the Steady-State Electrical Network (SSEN). With delivery and inspection of all power transformers having been completed, the process of transferring ownership to the ITER Organization has started. The transfer also includes ownership of the supplier's warranty and site support acknowledgement. In addition, the Final Delivery Report for Power Transformer Lots 1 and 2 has been drafted and is under internal review.

Diagnostics (R. Feder):

Upper Wide-Angle Visible and Infrared Viewing (UWAVs): Significant progress was made on the camera and filter design for the Back End Optical Chamber (BEOC). The BEOC optics transmits the optical signals into visible and infrared cameras. Discussions centered around whether the mechanical design is sufficient for PDR and effort should shift to documentation. Recent discussions with ORNL regarding the heat exchanger design clarified requirements for a key silicon carbide component, requiring further design adjustments before shifting the focus of the effort to documentation needed for next year's preliminary design review.

Upper port plug integration: The Upper Port 14 Load Specification was uploaded to US ITER iDocs and transmitted to the I-Central Team. A prioritized plan for the development of load specification for US ITER diagnostic systems, in preparation for the upcoming preliminary design reviews, was created. In addition a revised quality plan for Upper Ports and UWAVs and a revised Quality and Safety classification for Upper Ports have been approved by USITER.

NSTX-U RECOVERY PROJECT (R. HAWRYLUK):

Preparations are underway for the second Extent of Condition Review Committee. Completed roll-up of chits from last seven DVVR's into Proposed Corrective Action Spreadsheet. This includes input from Responsible Engineers (REs) on impact and cost/schedule for mitigation, and input from NSTX-U management on proposed action (Necessary for Start-Up, Strongly Recommended for Start-Up, Recommended for Start-Up, etc.). The final total of ~ 1200 chits have been condensed into ~ 450 issues. The spreadsheet, an overview talks and responses to the committee's previous recommendations were provided to the committee.

Dry runs of presentations for the upcoming Extent of Condition (EoC) review have started, and will continue into the coming week. As talks are completed, they will be posted.

Recommissioning of the coil winding facility also continued with the test bending and setting of conductor into a lead block, and the preparations of the lead block VPI mold. A peer review of procedures for the fabrication of a PF-1A prototype is scheduled for this coming Friday. An extension to the oven is being set up in case it's needed during the VPI of a PF-1A prototype. PPPL staff witnessed the priming of PF1 conductor at Everson Tesla.

NSTX-U RESEARCH (J. MENARD):

The ITPA Transport & Confinement Topical Group meeting was hosted at PPPL (local host Walter Guttenfelder) May 1-3. Topics discussed included particle transport during pellet fueling (TC-25), progress on neural net implementation of transport models (TC-29), validation of quasi-linear transport models, phenomenology and modeling of the transition between LOC-SOC confinement regimes (TC-21), particle pinch vs. collisionality (TC-15), update on the ITER confinement database (TC-28), and impurity transport (TC-11). There was also extended discussion on how to organize the Transport & Confinement section of the ITER Physics Basis Update as requested by the ITPA Coordinating Committee. The next ITPA T&C meeting will be held in Helsinki, Finland September 18-20.

S. Kaye chaired the TRANSP User Group (TUG) Meeting held at PPPL May 4-5.

ITER & TOKAMAKS (R. NAZIKIAN):

Presentations and publications: An invited review article by S. Zweben has just been published in Review of Scientific Instruments, titled "Gas puff imaging diagnostics of edge plasma turbulence in magnetic fusion devices". This review was based in part on the work done for the PPPL - C-Mod collaboration on Gas Puff Imaging (GPI).

R. Nazikian and F. Poli gave plenary talks at the US-EU Transport Task Force Meeting held in Williamsburg Virgina. Nazikian spoke on the transport effects of 3D fields in the H-mode pedestal and Poli spoke on the role of transport predictions in experimental planning. Brian Grierson with Orso Meneghini (GA) and Sterling Smith (GA) presented a tutorial on using TRANSP for interpretive and predictive transport analysis.

A. Ashourvan presented a TTF talk on the validation of a model for plasma intrinsic rotation on DIII-D. S. Haskey presented a poster on low and high collisionality main-ion rotation in the steep gradient region of H-mode plasmas, showing large main-ion flows near the separatrix that greatly exceeds the impurity rotation velocity. These two presentations build on the main ion CER work under Brian Grierson's early career award.

V. Duarte, a visiting graduate student working with N. Gorelenkov, presented a TTF plenary talk on the "Quasilinear relaxation formalism for energetic particle interaction with Alfvénic modes". Gorelekov presented a talk on the "Critical gradient and resonance broadened quasi-linear models for fast ion profile relaxation in fusion plasmas". These presentations reported on

progress towards the PPPL notable outcome on predictive modeling of fast ion transport in DIII-D plasmas.

Nazikian gave a remote presentation to the ITPA Pedestal and Edge Physics group on the characteristics of mitigated ELMs in fully non-inductive hybrid plasmas in DIII-D using 3D magnetic fields. A. Bortolon and L. Cui attended the meeting in York United Kingdom and gave presentations on ELM mitigation by D_2 and Li pellet injection and energy confinement recovery with Resonant Magnetic Perturbations in DIII-D, respectively. R. Maingi of PPPL chaired the meeting.

Student intern M. Vorenkamp, working with A. Nagy (PPPL) at DIII-D, published a paper in Fusion Science and Technology on recent upgrades to the DIII-D Impurity Granule Injector that allowed for the use of sub-millimeter granules other than lithium. These granules are used to trigger ELMs.

International: Bob Mumgaard (PSFC) assembled and aligned all ten PPPL-MIT MSE background polychromators during a weeklong visit to NFRI. The systems assembled without incident and alignment proceeded smoothly. The system will be used to determine if improved MSE measurements can be obtained on KSTAR over a wide range of plasma density.

DIII-D: N. Logan and L. Cui lead an experiment on DIII-D to characterize multi-modal NTV torque using 3D fields and compare observations to theoretical predictions using the recently developed Generalized Perturbed Equilibrium Code (GPEC).

Z. Wang carried out an experiment on DIII-D to determine ideal and resistive damping rates for stable MHD modes. The experiment is motivated by MARS-F studies indicating that the plasma response to time varying 3D fields can be used to determine the proximity of the plasma to ideal MHD stability limits.

The neutral beam pole shield fabrication job, under the leadership of I. Zatz, is proceeding smoothly towards a mid- to late-June delivery. The copper plates are in the late stages of machining prior to installation of the water-cooling channels. The molybdinum inserts are 70% complete.

ADVANCED PROJECTS (H. NEILSON):

Stellarators (D. Gates):

On May 1, D. Gates presented a seminar entitled “Stellarator Research Needs for Fusion Energy Development” at the University of Wisconsin-Madison as part of the weekly plasma seminar series. The talk was similar to a webinar presented last week that summarized the contents of a soon to be finalized report developed by the National Stellarator Coordinating Committee (NSCC). Dr. Gates also met with Professors Fonck, Hegna, Schmitz, and Anderson to discuss the organization and contents of the NSCC Budget Planning Meeting.

On May 4, Gates attended the NSCC Budget Planning Meeting, which was held at DOE Headquarters in Germantown, Maryland. The presentation covered the stellarator program vision

and the prioritized research needs as described by the program leadership. The program needs covered both long and short-term program visions. Stellarator scientists that represent a cross-section of the community as well as FES staff including senior management attended the talk. The talk was very well received.

System Studies (C. Kessel):

X. Cheng, L. Liu, H. Neilson, P. Titus, and C. Kessel participated in a conference call with ASIPP. Cheng presented her work on safety simulations for a loss of coolant accident with RELAP5 and CFX. Liu presented his work on the CFETR plasma current ramp-up and flattop phase using TSC and ONETWO. Cheng and Liu are visiting PPPL for approximately 1 year or so, and are contributing to the CFETR design assessments.

C. Kessel participated in the Budget Planning activity at DOE headquarters in Germantown, Maryland, representing fusion nuclear science in the Virtual Laboratory for Technology, led by Phil Ferguson. Brian Wirth (fusion materials), Brad Merrill (FNS), and Leslie Bromberg (enabling technologies) joined him. He presented the ongoing activities for a range of technical areas including PMI/PFC, high heat flux/PFC, liquid metal PFC, nuclear analysis, tritium behavior and safety, SOL/divertor modeling, and liquid metal/solid breeder science. In addition, he gave several opportunities for new and high impact work that could be done in these areas. The interaction with FES personnel was productive and started the process of having the fusion nuclear science; PMI/PFC, tritium science, and fusion material science communities talk with a single voice to the DOE.

THEORY (A. BHATTACHARJEE):

Members of the Theory Department attended the International Sherwood Fusion Theory Conference in Annapolis, Maryland this week. The following talks and posters were presented: Caoxing Zhu, who is currently visiting PPPL from University of Science and Technology of China, won the Student Poster Award with his presentation titled “Flexible optimized coil designing method using space curves”. PPPL Theory poster presentations were given by D. Brennan “Energetic ion effects on resistive instabilities with plasma rotation and a resistive wall”; F. Ebrahimi “Three-dimensional plasmoid-mediated reconnection in tokamaks"; N. Ferraro “Disruption Modeling with M3D-C1”; R. Hager “A gyrokinetic study of non-turbulent plasma response and transport induced by resonant magnetic perturbations”; G. Hammett “Gyrokinetic continuum simulations of turbulence in LAPD and in a helical model of a tokamak scrape-off-layer”; S. Hudson “Smooth magnetohydrodynamic equilibria with arbitrary, three-dimensional boundaries”; W.W.Lee “Finite Larmor Radius Effects at the Tokamak Edge and the associated MHD Equilibria”; C. Liu “Scattering of a runaway electron beam by whistler waves”; Denis St-Onge “The Dimits Shift in a One-Field Fluid Model”; D. Pfefferle “M3D-C1 modeling of tokamak vertical displacement events”; and Y. Zhou “Fabricating current singularity in a 3D line-tied plasma”. S. Ku presented an invited talk “Gyrokinetic simulation of a fast L-H like bifurcation dynamics in a realistic diverted tokamak edge geometry”. The abstract reads, “Despite its critical importance in the fusion program and over 30 years of H-mode operation, there has been no fundamental understanding at the kinetic level on how the H-mode bifurcation occurs. We report the first observation of an edge transport barrier formation event in an electrostatic gyrokinetic simulation carried out in a realistic C-Mod like diverted tokamak edge

geometry under strong forcing by a high rate of heat deposition. The results show that the synergistic action between two multiscale dynamics, the turbulent Reynolds-stress driven and the neoclassical X-point orbit loss drive sheared ExB flows, works together to quench turbulent transport and form a transport barrier just inside the last closed magnetic flux surface. The synergism helps reconcile experimental reports of the key role of turbulent stress in the bifurcation with some other experimental observations that ascribe the bifurcation to X-point orbit loss/neoclassical effects. The synergism could also explain other experimental observations that identified a strong correlation between the L-H transition and the orbit loss driven ExB shearing rate. The synergism is consistent with the general experimental observation that the L-H bifurcation is more difficult with the łB-drift away from the single-null X-point, in which the X-point orbit-loss effect is weaker." T. Stoltzfus-Dueck presented an invited talk: "Parasitic Momentum Flux in the Tokamak Core". The abstract reads "Tokamak plasmas rotate spontaneously in the absence of applied torque. This so-called 'intrinsic rotation' may be very important for future low-torque devices such as ITER, since rotation can stabilize certain instabilities. In the mid-radius 'gradient region,' which reaches from the sawtooth inversion radius out to the pedestal top, intrinsic rotation profiles are sometimes flat and sometimes hollow. Profiles may even transition suddenly between these two states, an unexplained phenomenon referred to as rotation reversal. Theoretical efforts to identify the origin of the mid-radius rotation shear have focused primarily on quasilinear models, in which the phase relationships of some selected instability result in a nondiffusive momentum flux ("residual stress"). In contrast to these efforts, the present work demonstrates the existence of a robust, fully nonlinear symmetry-breaking momentum flux that follows from the free-energy flow in phase space and does not depend on any assumed linear eigenmode structure. The physical origin is an often-neglected portion of the radial ExB drift, which is shown to drive a symmetry-breaking outward flux of co-current momentum whenever free energy is transferred from the electrostatic potential to ion parallel flows. The resulting rotation peaking is counter-current and scales as temperature over plasma current. As originally demonstrated by Landau, this free-energy transfer (thus also the corresponding residual stress) becomes inactive when frequencies are much higher than the ion transit frequency, which may explain the observed relation of density and counter-current rotation peaking in the core. Simple estimates suggest that this mechanism may be consistent with experimental observations, in both hollow and flat rotation regimes."

On May 4, Yasutaro Nishimura (National Cheng Kung University, Taiwan) presented a theory seminar on the disintegration threshold of Langmuir solitons in inhomogeneous plasmas. Dynamics of Langmuir solitons in inhomogeneous plasmas is investigated numerically employing Zakharov equations. The solitons are accelerated toward a lower background density side. With the steep density gradients, balance between the electric field part of the soliton and the density cavity breaks and the solitons disintegrate. The disintegration threshold is given by regarding the electric field part of the soliton as a point mass moving along the self-generated potential well produced by the density cavity. On the other hand, when the density gradient is below the threshold, Langmuir solitons adjust themselves by expelling the imbalanced portion as density cavities at the sound velocity. When the gradient is below the threshold, the electric field part of the soliton bounces back and forth within the potential well. The study is extended to kinetic simulation. Generation mechanism of high-energy electron tails in the presence of solitons is discussed. The electron distribution function resembles that of the Lorentzian type. The particle acceleration is explained as a transport process toward high-energy side due to overlapping of multiple resonant islands in the phase space.

Computational Plasma Physics Group (S. Jardin):

The second TRANSP User's Group meeting was held at PPPL on May 4-5. Over forty-five TRANSP user's and developers participated in the meeting, with approximately thirty-five on site and a dozen remotely connected from around the world. The purpose of the meeting was to discuss TRANSP development progress and hear from users about how they use the code and what their needs are. This information will help prioritize TRANSP development plans. Of particular interest to the users was the work the CPPG is doing in implementing IMAS and TRANSP/NUBEAM use within that, RF and fast ion distribution function algorithm implementation, pellet ablation models, TRANSP as a plasma proxy for control algorithm development within the SIMULINK framework, speed-up of predictive TRANSP runs based on the TGLF core transport model, and core-pedestal-SOL coupling. There was also much discussion about how communications among TRANSP users and developers could be improved. S. Kaye from PPPL organized and chaired the meeting.

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