Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY
U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending July 11, 2020, are as follows:

NSTX-U RECOVERY (J. GALAYDA) AND RESEARCH (S. KAYE)

Recovery (J. Galayda):

Coils — PF1B Lower, the first coil fabricated by Sigmaphi, underwent dimensional inspections in preparation for the start of low-power electrical testing early next week. In France, coil fabrication continued and final paperwork was reviewed for PF1A#1; this coil will be shipped to PPPL at the end of this week. In addition, the curing period for PF1A#2 neared completion for vacuum pressure impregnation (VPI). PF1B#2 coil winding was completed and the coil was prepared for VPI. PF1C#1 VPI and testing were both completed this week and the Project is awaiting the test reports review before shipping preparations begin. PF1C#2 brazing of the coil flags was finished, and preparations for VPI began. In addition, the order for spare coils was processed; the Red Book is with the DOE for approval prior to placement of the order.

Center Stack Casing (CSC) — Machining continued in Camden, New Jersey, on the center stack casing this week. The machining will resume on two shifts and weekends next week at the Holtec facility in Camden. This phase of machining will continue through July 24, when the CSC will be shipped to Turtle Creek to attach the collar pieces on each end. It will then be returned back to Camden in early August for more machining.

Machine Core Structures (MCS) — Many fabrication activities continued at the three facilities currently making sling parts. Precision Boring in Michigan will ship PF1B sling component parts to PPPL this week, with the upper parts to follow in mid-July. In addition, fabrication of the PF1A and PF1B capture and common flanges and PF1C capping flanges for the sling supports continued this week. In South Carolina, Carolina Fabricators' first articles and production of PF1A sling parts continued this week. Also, G. J. Oliver finished radiograph inspection and resumed final machining of the welded parts for the PF1C supports. The preload parts were at Magnaplate this week being coated. Additional procurement activities to award contracts for the remaining MCS components neared completion.

PF1A and PF1B Coil Assembly and Assembly Fixture Peer Review — A peer review was held July 8 to review the PF1A and 1B coil assembly and to review each subassembly process needed to identify potential component mating issues. The review also covered the assembly fixture needed in preparation for the high-power testing of the replacement inner PF coils residing in coil support structures.

Weekly HIGHLIGHTS

Research (S. Kaye):

S. Banerjee of The College of William and Mary presented, "The Correlation of Pedestal Fluctuations and Inter-ELM Recovery Leading to Reduced ELM Frequency in ECH Dominated Discharges on DIII-D," at the PPPL Magnetic Fusion Seminar on July 6. The work focused on the turbulence observed during inter-ELM periods, and its correlation with the post-ELM recovery of the electron temperature and density profiles. Linear eigenmode analysis indicated that MTM and TEM modes were the most likely modes that were driven by the enhanced electron temperature gradient immediately following the ELM. The increase in transport due to these modes delayed the gradient recovery, and therefore reduced the ELM frequency in ECH-dominated discharges.

An NSTX-U/ST-40 ECH collaboration Zoom meeting was held on July 8 with the ST-40 researchers V. Shevchenko, S. McNamara, P. Thomas, and ST-40 graduate student P. van de Glessen. NSTX-U researchers M. Ono and N. Bertelli presented a promising and efficient ST-40 start-up and ramp-up scenario for the low-field-side 140 GHz x-mode ECH/ECCD for the BT = 2.4-3.0 T regime.

U.S. ITER FABRICATION (H. NEILSON)

Electron Cyclotron Emission- ECE (G. Paraiso)

The ECE team continues to update the CAD model, to repositioning the optical components in order to adapt to the new shield module structure. An assessment of the assembly showed a need for redesign of several components. Conceptual redesign work on the shutter mirror has begun. It was also found that ITER's window assembly design has been updated since 2017, requiring modification to the interface feature on the ECE compliant seal which mounts to the window flange. Modification of the compliant seal is in progress and will be coordinated with India's ITER team, a partner in the ECE diagnostic.

Toroidal Interferometer Polarimeter - TIP (M.-A. de Looz)

The TIP team is reviewing the requirements for ex-vessel overhead supports, which are planned to be installed prior to first plasma. Of prime importance are the elements of the system, consisting of laser light tubes and associated overhead support structures, which penetrate the boundary between the tokamak building and the diagnostics hall. A meeting with ITER Central Team counterparts clarified the timeline for completion of the design and other information needed for installation by the ITER assembly team.

Weekly HIGHLIGHTS

Equatorial Port 9 Integration - EP09 (A. Basile)

A joint structural and thermal analysis, involving EP09 and its tenant diagnostics ECE and TIP, was launched to study the displacements and stresses with the generic diagnostic shield module (DSM) design. Structural and thermal deflections as a result of applied operational loads are highly important for TIP, which uses infrared laser light and must be highly precise to offer its intended measurement performance. The baseline study will aid in the initiative to redesign the TIP mirror mounting system within the DSM to meet goals. The joint study is being conducted by PPPL engineer B. Linn.

ITER & TOKAMAKS (R. NAZIKIAN)

DIII-D (B. Grierson)

Research:

B. Grierson attended and presented at the spring ITPA Transport and Confinement virtual meeting. Grierson presented plans for an upcoming experiment on DIII-D to investigate the turbulence and transport in hydrogen plasmas with high electron-to-ion temperature ratio in support of ITER's first pre-fusion power operational phase PFPO-1.

This week PPPL physicists N. Logan and Q. Hu led experiments on the DIII-D tokamak to study MHD and turbulent effects on density pump-in and pump-out under the application of 3D magnetic fields. The experiment examined the dependence of pump-in vs. pump-out on plasma rotation using various mixes of co- and counter-current NBI torque injection to manipulate the edge rotation profile. The regimes explored included states with ExB precession in the opposite direction as the electron diamagnetic precession, and particles were observed to pump in when 3D fields were applied, consistent with resonant MHD induced transport models.

International PMI and FES LM PFC Development Program (R. Maingi):

A. Fisher (PU) presented a talk at the bi-weekly liquid metal PFC development meeting titled, "Ideas on development of low recycling lithium divertor with minimal lithium inventory, power and flow speed requirement." Experiments with the "divertorlet" concept on LMX at PPPL were presented.

R. Maingi and Z. Sun participated in a bi-weekly conference call with the University of Illinois at Urbana-Champaign (UIUC) on analysis of thermocouple data from the liquid lithium limiter experiments at EAST, using the LIMIT tile concept. Good progress toward development of an interpretive analysis tool was presented by UIUC graduate student D. O'Dea.

ADVANCED PROJECTS (D. GATES)

Stellarators (D. Gates)

N. Pablant presented a report at the CWGM (stellarator coordination meeting) for the Joint Experiment: Low-Density Neoclassical Physics (CERC). This activity (JEX1) has been very successful over many years in helping organize international collaboration and joint papers toward validation of neoclassical stellarator physics in low-density electron-root plasmas. After the report, Pablant led a discussion on a change of scope for JEX1 toward an activity that also encompasses higher-density plasmas that is more aligned with current research interest on stellarator NC physics.

The paper titled, "Topology optimization of permanent magnets for stellarators," by C. Zhu, K. Hammond, T. Brown, D. Gates, M. Zarnstorff, K. Corrigan, M. Sibilia, and E. Feibush has been accepted for publication by *Nuclear Fusion*. This paper describes a topology optimization method to design permanent magnets for advanced stellarators. It summarizes the recent effort in developing the FAMUS code for designing engineering-feasible permanent magnets satisfying the constraints of the maximum material magnetization and explicit forbidden regions. Three different permanent magnet designs together with planar TF coils for a half-Tesla NCSX configuration have been obtained for demonstrations. The results show that FAMUS is a flexible, advanced numerical tool for future permanent magnet stellarator designs.

A paper by F. Nespoli and coauthors titled, "First impurity powder injection experiments in LHD," was submitted to *Nuclear Materials and Energy*. The article reports on the first set of experiments performed on LHD employing the PPPL-developed and -built Impurity Powder Dropper. The successful injection of boron and boron nitride powder into the helical plasma is confirmed by multiple diagnostics. The prompt effect on the plasma of the impurity injection is characterized. The transport of the created boron ions is analyzed and found to differ qualitatively in low-/high-density plasmas, due to both different dynamics of the powder grains and the different direction of the ambipolar radial electric field.

Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY

U.S. DEPARTMENT OF ENERGY

THEORY (S. HUDSON)

An ECP Milestone Report (ADSE12-18) titled, "Demonstration of WDMApp with kinetic electrons on Summit," was submitted by J. Dominski, J. Cheng, G. Merlo, E. Suchyta, S. Parker, F. Jenko, C.S. Chang, and A. Bhattacharjee. This document reports the results on the coupling of core and edge gyrokinetic simulations with kinetic electron physics. Previous milestones treated the coupling of core and edge when electrons are adiabatic (ADSE12-15 and ADSE12-7). The inclusion of kinetic electrons makes both physics and algorithmic aspects of the coupling of core and edge simulations more complex and challenging. Yet this complexity is needed because there are important types of turbulence that cannot be described by the adiabatic electron model.

J. Dominski gave a remote seminar for the Swiss Plasma Center titled, "First-principles spatial coupling of core and edge gyrokinetic simulations: Towards high-fidelity modeling of whole tokamak device."

S. Jardin submitted the third quarterly progress report on the FY2020 Theory Milestone titled, "Modeling of fully 3D vertical displacement event disruptions." The third quarter milestone involved performing and documenting benchmark M3D-C1/NIMROD 3D VDE calculations in simplified geometry.

COMMUNICATIONS & PUBLIC OUTREACH (A. ZWICKER)

Science Education (A. Zwicker):

Communications (L. Bernard):

The Office of Communications posted one press release to the PPPL website. It reported that virtual stellarator conferences have had much larger attendance and wider participation than in-person conferences have had. The story was also posted to the *Newswise* and *EurekAlert* press release distribution services.

L. Bernard participated in the DOE Office of Science, Office of Communications and Public Affairs virtual meeting with National Laboratory communications offices on July 9.

Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY

U.S. DEPARTMENT OF ENERGY

DIRECTOR'S OFFICE (S. COWLEY):

Laboratory leadership has been communicating ongoing updates to staff regarding the COVID-19 virus and PPPL.

On July 10, S. Cowley participated virtually in the National Laboratory Directors Council (NLDC) COVID-19 Coordination conference call.

On July 10, J. Menard participated in the weekly National Virtual Biotechnology Laboratory (NVBL) working group call.

This report is also available on the following web site:

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