Weekly HIGHLIGHTS

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

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

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

Recovery (J. Galayda):

Coils — Winding of the PF1A lower coil began at Sigmaphi in France and conductor is being wound at the prescribed rate with no issues. PPPL engineers and Quality Assurance are in France to provide oversight of the fabrication. In addition, the second winding line passed its manufacturing readiness review (MRR). After satisfactory completion of the vacuum testing for the PF1B lower coil mandrel this week, the mandrel will be installed onto the winding line and PF1B lower coil fabrication will begin.

Center Stack Casing — All forgings were received at the Holtec Turtle Creek facility and satisfactorily passed inspection. The various components are being prepped for assembly, which will start next week. PPPL personnel will be on site next week to observe the fit-up and start of welding activities.

NSTX-U Test Cell — The subcontractor will complete conduit installation this week for the radiation monitoring system and begin installing electrical cables next week. Labyrinth roof shield blocks were received on Jan. 7. Installation will be completed in late February or early March. The subcontractor continues to install shielding in the test cell shield wall.

Field Seal Repairs FDR — A final design review (FDR) was held on Jan. 7 for the field seal repair flange bay placement and assess the design progress since the conceptual design review (CDR). The proposed design replaces the wire-seal flanges for each of the five flange bays by cutting off the existing flange and welding a new flange on the vacuum vessel spool piece. The review also addressed the design of the flange removal and a leak check of the fixtures.

Vacuum Vessel G10 Insulation Mockup Results Peer Review — A peer review was held on Jan. 8 to address mockup testing results for the vacuum vessel upper support G10 electrical insulation. The mockup tests used electrically insulated materials injected at metal-to-G10 interfaces to enhance electrical insulation.

Bakeout System Final Design Review — A final design review covering three topics was held on Jan. 10 for the NSTX-U bakeout operational system. The bakeout system consists of three complementary system components: the helium heating system, center stack ohmic heating system, and vacuum vessel water heating system. As a result of the extent of condition (EoC) review, several recommendations were made to

improve the bakeout system for each component. The FDR was held to review the new design schemes per the EoC recommendations.

Research (S. Kaye):

The paper, "Disconnection of SOL Turbulence Between the Outer Midplane and Divertor Target Plate in NSTX," by F. Scotti, et al. was published in *Nuclear Fusion*: https://doi.org/10.1088/1741-4326/ab5886). The paper examines the connection between SOL turbulence at the outer midplane and at the divertor target plate in NSTX L-mode discharges through a comparison of fluctuation levels, correlation lengths and velocities, and cross-correlation between midplane and divertor turbulence. Strong correlation between divertor and midplane turbulence is observed in the far SOL. The correlation progressively decreases towards the separatrix, along with the decrease in the measured divertor fluctuations. The reduction in correlation was consistent with expectations from an electrostatic two-region blob model (Myra *et al* 2006 *Phys. Plasmas* **13** 112502) with turbulence disconnection caused by X-point geometry.

The paper, "Shattered Pellet Penetration in Low and High Energy Plasmas on DIII-D," by R. Raman, R. Sweeney, R. Moyer, N. Eidietis, D. Shiraki, J. Herfindal, J. Sachdev, E. Hollmann, S. Jardin, L. Baylor, R. Wilcox, T. Carlstrom, T. Osborne, D. Eldon, J. Menard, R. Lunsford, and B. Grierson was published on-line in *Nuclear Fusion*: https://doi.org/10.1088/1741-4326/ab686f. In support of ITER needs, the depth of SPI fragment penetration in DIII-D plasmas was investigated by injecting SPI into two discharges with vastly different energy content and pedestal height. 400 Torr-L pure Ne fragmented pellets at a velocity of about 200 m/s were injected into a 0.2 MJ L-mode discharge and a 2 MJ super H-mode discharge. Results show deep penetration of SPI fragments into low-energy plasmas in DIII-D. SPI fragment penetration is reduced as the plasma energy content increases, with some discharges exhibiting penetration that is confined to the outer regions of the plasma. Studies such as these should provide the needed data for 3d MHD simulations, as reliable simulations (benchmarked against experimental results from present tokamaks) is the only way to reliably project to ITER plasmas.

U.S. ITER FABRICATION (H. NEILSON)

A design analysis and calculation (DAC) report concentrating on overhead Low Field Side Reflectometer (LFSR) waveguide supports in the ITER tokamak building was recently approved by the ITER central team. The report was produced as part of a 2019 study to analyze the acceptability of changing the overhead supports from a custom solution to a commercially available off-the-shelf (OTS) option. The study concluded that the switch

satisfies the structural needs vis-a-vis the environmental constraints including (but not limited to) fire and earthquake events. The OTS option has clear advantages for simplicity and cost of installation, requiring less labor and enabling common designs of support systems beyond even the LFSR project. The DAC report, by PPPL engineer M. de Looz, documents the study and is now approved by stakeholders at the ITER Central Team, indicating its full acceptance as the approved support solution.
The ITER Diagnostics team is focused now on finalizing details of the LFSR antenna assembly in preparation for a final design review and start of manufacture. More detailed, comprehensive and final tolerance assessments are under way; the outcome will directly contribute to final drafts of LFSR fabrication drawings and other design documentation. A detailed study of in-vessel pipe weld joint preparation techniques has been launched to finalize LFSR water pipe configuration in conformance with ITER vacuum component requirements.

ITER & TOKAMAKS (R. NAZIKIAN)

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

R. Maingi and Z. Sun participated remotely in an experiment on EAST in which a fourth-generation flowing liquid lithium limiter was inserted into EAST plasmas with up to eight megawatts of auxiliary heating. A LIMIT-style grooved plate with vertical channels was used, along with a mechanically improved mounting system for the limiter. D. Andrucyzk and S. Stemmley (UIUC) led the experiment onsite at ASIPP. A heating power scan, a plate radial position scan (within two centimeters of the separatrix), a surface temperature scan, and a helium cooling rate scan were all obtained. All in all, the plate performed quite well.

A periodic meeting of the domestic liquid metal PFC development program was held. S. Smolentsev (UCLA) reported on liquid metal flow considerations for several plasma-facing component geometric layouts for a Fusion Nuclear Science Facility (FNSF); new calculations are expected in the next couple of months. E. Kolemen (PU) reported on a recent result and potential upgrade paths for the LMX.

THEORY (S. HUDSON)

A paper titled, “PT-symmetry entails pseudo-Hermiticity regardless of diagonalizability,” was published on Jan. 2 in the *Journal of Mathematical Physics*: https://aip.scitation.org/doi/full/10.1063/1.5117211. H. Qin is the corresponding author of the paper. Pseudo-Hermiticity is a concept in quantum mechanics proposed by Dirac in the 1940s, and PT-symmetry is an active research topic across all branches of physics

initiated by Bender in 1998. Proving the surprising result that PT-symmetry entails pseudo-Hermiticity establishes the important fact that spontaneous PT-symmetry breaking, observed in both quantum and classical systems, is necessarily and sufficiently triggered by the resonance between two particles or eigenmodes with different signs of actions.

COMMUNICATIONS & PUBLIC OUTREACH (A. ZWICKER)

Communications (L. Bernard):

The Office of Communications posted one press release to the PPPL website. It focuses on research by V. Duarte and N. Gorelenkov, who have used a simple insight to capture the complex effects of many high-frequency waves in a fusion plasma. These waves can force hot particles to escape from a fusion reactor, potentially impairing fusion energy production and damaging the reactor walls. The story was also posted to the *Newswise* press release distribution service.

This report is also available on the following web site:

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