Weekly HIGHLIGHTS

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

The PPPL Highlights for the week ending November 9, 2019, are as follows:

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

Recovery (J. Galayda):

HTT/HTP — PPPL technicians working with D. Cai and S. Sheckman successfully manufactured, heat-treated, and installed the first heat transfer tube (HTT) for IBDV cooling. The tubing was also fit-up into the old center stack casing (CSC) and met all dimensional tolerances. A second HTT will be manufactured, and both will be shipped to ORT/Holtec for installation into the new CSC in early 2020.

NSTX-U Test Cell — Dufrane Shielding completed construction of four of the five test cell labyrinth roof shield blocks this week. Job orders for the installation of the NSTX-U test cell neutron shielding were issued to blanket order agreement subcontractor 3BD.

PF Coils — Project personnel discussed options for schedule recovery with the vendor. The project team is working with a vendor executive to overcome staffing limitations that may become a barrier to schedule recovery. NSTX-U management is examining alternatives to prevent schedule slippage.

Vessel Support Leg G10 Insulation Replacement Peer Review — A peer review was held Nov. 7 for the NSTX-U vessel support leg G10 insulation replacement. During a second field scope preliminary design review (PDR-2) held on Oct. 10, clear signs of damage to the vessel support G10 insulation were discovered, along with discoloration of the G10 shims due to electrical arcing and misalignment. This peer review went over proposed solutions to replace damaged insulation sheets, G10 bushings, and G10 plates to ensure electrical insulation and to meet performance requirements. The resolution of these issues will close an outstanding chit submitted during a previous design verification and validation review (DVVR).

Wire-Seal Bay H & F Flange Seal Repair Peer Review — An additional peer review was held on Nov. 7 to review metrology data for bays F and H in the NSTX vacuum vessel and the proposed solutions to repair leaks in these two flange bays. During the NSTX-U run in 2016, wire-seal flange bays I, H, and F in the vacuum vessel were identified as sources of significant vacuum leaks. A conceptual design review (CDR) for seal repair options was held on Sept. 17.

Research (S. Kaye):

F. Poli traveled to Hefei (People's Republic of China) to attend the 3rd AAPPS-DPP Conference on Plasma Physics. She gave an invited talk about her work on identifying controllable trajectories for the ITER current ramp-down phase and chaired a session on edge modeling.

U.S. ITER FABRICATION (H. NEILSON)

A recent report from ITER Diagnostics design partner General Atomics (GA) addresses the impact of stray microwaves from high-power electron cyclotron heating (ECH) that impinge on the Low Field Side Reflectometer (LFSR) antenna openings. The ITER Organization estimates that as much as five percent of the launched ECH power can pass through the plasma unabsorbed and scatter onto plasma facing surfaces with a continuous surface heat flux of 1.25 MW/m^2. The report, by GA's J. Doane, explains that these waves will back-propagate up the LFSR waveguides until they reach a right-angle bend that features a diffraction grating designed to scatter stray microwaves onto the walls of the waveguides. Because stray heat loads from unabsorbed ECH are continuous, the heating of LFSR components can be significant over the course of an hour-long pulse. In light of these newly recognized loads, the LFSR engineering team has modified the design to improve both the direct and indirect cooling of LFSR components and provide increased margin against overheating due to stray ECH microwave power.

ITER & TOKAMAKS (R. NAZIKIAN)

DIII-D (B. Grierson)

Research:

The paper titled, "High frequency pacing of edge localized modes by injection of lithium granules in DIII-D H-mode discharges," by A. Bortolon, et al. has been nominated for the 2019 Nuclear Fusion Award. Nominated papers are judged to be those of the highest scientific standard, selected from the journal volume published two years prior to the award year.

An experiment was executed on DIII-D this week to test the performance of the new co/counter off-axis neutral beam operating in the off-axis, counter-current direction. The experiment, led by B. Grierson, M. Van Zeeland (GA), I. Bykov (UCSD), S. Haskey, and K. Gage (UCI) performed visible imaging of the neutral beam injection, dedicated

discharges for assessing the neutron rate produced by injecting each of the beams and tested the ability to balance the neutral beam torque between the off-axis co-injection 150-degree beams and the off-axis counter-injection from the 210s.

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

R. Maingi served on the Ph.D. defense committee of T. Younkin, a student at the University of Tennessee, Knoxville. The thesis title is, "Fusion Machine Scale Wall Material Erosion and Redeposition Modeled with GITR as a Part of an Integrated Simulation to Evaluate Tungsten Plasma-Facing Component Lifetimes and Feedback on Fusion Plasmas."

The paper titled, "Multiple striated heat flux patterns on the EAST first wall generated by lower hybrid wave absorption in the scrape-off layer," by K. Gan, M. Li, X. Gong, R. Maingi, B. Zhang, M. Chen, T. Gray and B. Wirth was published in *Physics of Plasmas*. The paper concludes that the striated heat flux patterns originate from damping of the lower hybrid heating waves in the scrape-off layer. Simple field line tracing and modulation on/off experiments confirm that the striations are independent of, e.g., injected power, which is in contrast to heat flux peaks near the strike points that scale with input power.

A. Khodak presented a poster titled, "Liquid metal modeling for plasma facing components" at the 6th IAEA DEMO Programme Workshop in Vienna, Austria, the week of Nov. 4. Liquid metal PFC melt layer dynamics were modeled with computational fluid dynamics and magnetohydrodynamics simulations. In summary, a flexible computational platform for simulation of interacting solids, fluids, and gases in the presence of highly collisional plasmas was documented.

International Long Pulse (F. Poli):

W. Choi and F. Poli traveled to Hefei, China, to attend the 3rd AAPPS-DPP Conference on Plasma Physics. Choi presented the first results from self-consistent TRANSP simulations of EAST plasma discharges with synergy between electron cyclotron and lower hybrid waves. This poster, entitled, "Simultaneous injection of lower hybrid power at two frequencies on EAST," won the AAPPS-DPP 2019 prize for the best poster. Poli gave an invited talk on her work on identifying controllable trajectories for the ITER current ramp-down phase. Poli also chaired a session on edge modeling.

ADVANCED PROJECTS (D. GATES)

Stellarators (D. Gates):

One of the challenges in the initial design of a permanent-magnet-based stellarator has been to specify an array of permanent magnets that create the required magnetic field while still being feasible to construct. To address this issue, a code has been developed by K. Hammond to automatically generate potential layouts of trapezoidal magnets whose strengths can then be optimized by the FOCUS-PM code which has been written by C. Zhu. Initial results indicate that, while the magnets must point obliquely toward the vessel, it is possible to arrange them in such that they can be mounted on flat, planar support structures.

A first release of the XICSRT code for X-ray raytracing and plasma simulation has been completed. The XICRT code has been designed with two goals in mind. The first is to improve the quality of analysis and reduce errors in the analysis existing X-ray diagnostics such as the XICS diagnostic on W7-X. The second goal is to study the expected performance of systems under designs such as for the ITER XRCS-Core diagnostic. This code has been jointly developed by N. Pablant (PPPL), SULI student Y. Yakusevich, and graduate student J. Kring (Auburn University). All of the essential features needed for complete modeling of the W7-X and ITER xics system have now been implemented. This includes optical components to model spherically bent crystals, Highly Oriented Pyrolytic Graphite (HOPG) pre-reflectors, pilatus detector, and VMEC based plasma simulations. Care has been taken to allow measurements with correct photon statistics given experimental or theoretical emissivity, temperature and plasma flow profiles. In addition to single system modeling, this tool can be used to produce perturbation studies leading to engineering design tolerances. This tool has already proved critical for improvement of XICS analysis at W7-X though the development of an ion temperature correction to take account for spherical aberration and the sub-pixel distribution of photons on the detector. Modeling of a new proposed design for the ITER XRCS-Core diagnostic is currently underway.

THEORY (S. HUDSON)

During the week of Nov. 4, V. Duarte visited the University of Texas, Austin, to work in collaboration with H. Berk on quasilinear modeling of fast ions. Duarte gave a talk titled, “Prediction of nonlinear evolution character of energetic-particle-driven instabilities.”

J. Dominiski gave an invited talk at the 3rd Asia-Pacific Conference on Plasma Physics (AAPPS-DPP2019) in Hefei, China. The title was, “Emerging picture on the triggering mechanism of ELMs.”

B. Sturdevant attended the Joint US-Japan Workshop on Post K-ECP Collaboration and 5th JIFT Exascale Computing Collaboration in Kobe, Japan, Oct. 28-29. He gave a talk titled, "An improved equation-free method."

S. Ethier gave two lectures at Princeton University's *Introduction to Parallel Programming Workshop 2019*. The event was organized and sponsored by the Princeton Institute for Computational Science and Engineering (PICSciE) and the Office of Information Technology (OIT) Research Computing. Ethier gave two full-afternoon sessions titled, "Introduction to Parallel Programming with OpenMP and MPI," and "Programming GPUs with OpenACC." The workshop was open to all students and researchers at Princeton University and PPPL. Lectures are posted here: https://princetonuniversity.github.io/PUparallel2019/agenda/

A. Miller, an undergraduate student from Columbia University who was a SULI student at PPPL last summer, received an "Outstanding Poster" award at the APS-DPP 2019 conference for his poster entitled, "A machine learning algorithm for the nonlinear Fokker-Planck-Landau collision operator in XGC."

DIRECTOR'S OFFICE (S. COWLEY)

S. Cowley traveled to Lausanne, Switzerland, Nov. 3-6, to participate in a review panel of the School of Basic Sciences at École polytechnique fédérale de Lausanne (EPFL).

C. Ferguson traveled to the United Kingdom and visited UKAEA for Nov. 8 meetings with senior management, as well as a tour of facilities including JET, MAST, and RACE.

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