Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending October 26, 2019, are as follows:

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

Recovery (J. Galayda):

Instruments & Controls — Cameras and fittings have been procured for the NSTX-U test cell surveillance system. These cameras will be used to monitor and record areas of interest during NSTX-U experimental and test operations, and video recorded during shots will be archived and made available to operations staff post-shot. The recovery project began the procurement process as soon as ESAAB approval was granted.

Test Cell Shielding — Interference removal has been completed, a contract to construct a new labyrinth wall has been awarded, and contractor mobilization, which includes the review of submittals, has begun. Concurrent with these activities, work on the shop-fabricated shield blocks continues. The blocks will be poured before the end of the month, with expected completion in Nov. 2019. PPPL engineering and QA staff are making inspections in the vendor's shop.

Plasma Facing Components (PFC) — A red book was prepared and submitted for DOE review; this book contained the documents needed to solicit proposals for graphite tile fabrication. Under this solicitation, PPPL will have the flexibility to promptly make multiple awards for graphite tile manufacturing, which is currently on the project critical path. The raw graphite material needed to manufacture the tiles was previously purchased by PPPL under advanced procurement authority.

Machine Instrumentation — A final design review (FDR) was held Oct. 25 for the Machine Instrumentation Fiber Optic Strain, Temperature, and Displacement Measurement System. This system is designed to provide data about real stresses, strains, and displacements observed by various machine components during operation. The data obtained with the system will be used to validate models to improve designs and will inform the process of assessing machine health and long-term reliability. The FDR detailed steps taken to validate and prototype the current design, examined plans for installing the system, and provided an updated cost and schedule estimate.

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Research (S. Kaye):

NSTX-U researchers attended the 61st Annual American Physical Society — Division of Plasma Physics meeting held in Fort Lauderdale, Florida, Oct. 21-25. Several gave invited talks: “Enhanced pedestal H-mode regime on NSTX,” by D. Battaglia; “Validation of gyrokinetic simulations in NSTX including comparisons with a synthetic diagnostic for high-k scattering,” by J. Ruiz Ruiz; and “Theory for control of sub-cyclotron Alfvén instabilities and implications for anomalous electron energy transport in tokamaks,” by J. Lestz. The latter two talks were based on Ph.D. thesis work done as graduate students.

U.S. ITER FABRICATION (H. NEILSON)

With the mechanical design of the Low Field Side Reflectometer (LFSR) antenna assembly nearly fixed, engineering analysis tasks are now under way. T. Willard has completed a time transient electromagnetic (EM) analysis on the “as installed” in-vessel LFSR system. The geometry for the analysis included (but was not limited to) the port plug structure, the diagnostic shield modules including shielding material, and the LFSR antenna support block, antennas, waveguides, and clamping hardware. The simulation was performed in ANSYS Maxwell. The objective was to determine the electromagnetic forces which the system will experience during a 0.4-second plasma disruption event. The output from the analysis is a distribution of body force densities (force per unit volume for each mesh element). The force density may be utilized as an input load for various structural analyses. This simulation is the most detailed EM analysis on the LFSR to date.

A summary of the progress in the LFSR antenna assembly final design was presented by PPPL engineer M. Duco on behalf of the LFSR team. Since the preliminary design review last November, the network of water-cooling channels in the antennas and their support block has been optimized and integrated with the cooling network of the enclosing shield structure. Design details of the support block have evolved to fit into a conformal cavity in the shield module, while ensuring compatibility with structural support, cooling, and remote handling. Attachments of the uncooled waveguides have been optimized to provide load path for heat removal and accommodate thermal expansion.

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ITER & TOKAMAKS (R. NAZIKIAN)

DIII-D (B. Grierson)

Research:

Two invited talks and six oral talks by the DIII-D collaboration were given at the 61st APS-DPP conference in Fort Lauderdale, Florida. The invited talk by R. Hager was titled, "Understanding the RMP-driven transport in tokamak edge plasma from gyrokinetic-MHD coupled simulation in realistic divertor geometry;" the invited talk presented by A. Bortolon was titled, "Real-time wall conditioning through boron powder injection in fusion devices with carbon and tungsten wall." Oral talks were as follows: A. Ashourvan, "Formation of a high pressure staircase pedestal with suppressed edge-localized-modes in the DIII-D tokamak;" B. Grierson, "Testing the DIII-D co/counter off-axis NBI performance for accessing high beta steady state scenarios;" Q. Hu, "The role of resonant field penetration in ELM suppression and density pump-out in the DIII-D tokamak;" G. Kramer, "Enhanced radial energy transport induced by radially curved Alfvén eigenmode wavefronts;" F. Laggner, "Improved density feedback control range and response time on DIII-D using 3D fields;" and N. Logan, "Multi-machine scalings of n=1 and n=2 error field correction."

International Long Pulse (F. Poli):

D. Boyer, W. Choi, and M. Podestà attended the 61st APS-DPP conference held Oct. 21-25 in Fort Lauderdale, Florida. Boyer and Podestà gave contributed oral presentations during the KSTAR session. Boyer presented control simulations with TRANSP and Simulink in a talk entitled, "Model-based control development for KSTAR enabled by TRANSP." Podestà discussed possible deterioration in performance of high-performance discharges by low frequency Alfvénic modes in a talk entitled, "Search for Alfvén sound eigenmodes in high-beta KSTAR plasmas." Choi presented a poster titled, "Simultaneous injection of lower hybrid power at two frequencies on EAST," which discussed simulations with TRANSP of EAST discharges with synergy between electron cyclotron and lower hybrid waves, from experiments conducted in May 2019.

ITER-JET (M. Podestà, F. Poli):

A. Teplukhina and P. Bonofiglo attended the 61st APS-DPP conference held Oct. 21 to 25, 2019, in Fort Lauderdale, Florida. Teplukhina presented a poster entitled, "Modelling of ICRF heating effects on the evolution of fast ion transport in plasmas with MHD instabilities." Bonofiglo presented recent results from the recommissioned JET Faraday

Cups diagnostic in a poster entitled, “Recommissioning the KA2 Fast Ion Loss Detector on JET in preparation for the DT campaign.”

During the APS meeting, M. Podestà, F. Poli, and N. Bertelli held a kick-off discussion with co-PIs from GA, ORNL and UCI within the ongoing JET/EU project aimed at validation of RF and fast ion transport models in TRANSP.

ADVANCED PROJECTS (D. GATES)

Stellarators (D. Gates):

Three members of the Stellarator Group attended the 61st Annual Meeting of the APS Division of Plasma Physics at Fort Lauderdale, Florida, Oct. 21-25. C. Zhu presented a poster titled, “Novel methods to design permanent magnets for stellarators.” In his presentation, he introduced two novel numerical methods to optimize permanent magnets for future stellarators with extremely simplified coils. He also joined the group meeting of the National Stellarator Coordinating Committee (NSCC) on discussing the stellarator strategy for the upcoming APS-DPP Community Planning Process. F. Nespoli presented the poster, “Filament dynamics in presence of X-point in turbulence simulations”, reporting on the disconnection of plasma filaments at the X-point in TOKAM3X simulations of WEST diverted plasmas.” K. Hammond presented a contributed oral on Oct. 24 titled, “Drift effects on W7-X edge heat and particle fluxes.” The talk discussed the results of a study of the effects of drift flows in the edge plasma of the Wendelstein 7-X stellarator that was recently published in *Plasma Physics and Controlled Fusion* (see below).

The paper titled, “Drift effects on W7-X divertor heat and particle fluxes,” by K. Hammond, et al., was published in *Plasma Physics and Controlled Fusion* on Oct. 23. The paper describes a series of experiments carried out on the Wendelstein 7-X (W7-X) stellarator in Greifswald, Germany, designed to study the effects of particle drift flows in the edge of the plasma. In all cases, drift flows were observed to cause asymmetries in the heat load patterns on divertor targets on the upper side of the plasma relative to those on the lower side. The asymmetries observed for low-density plasmas could be attributed to a drift flow mechanism with a close analogue in tokamak edge plasmas, whereas the drift effects at higher densities are not yet as well understood. The findings of the study have helped to clarify and isolate mechanisms that affect heat loads to plasma-facing components, an important parameter for fusion reactor operation.

THEORY (S. HUDSON)

C. Dong was appointed as a co-investigator on an instrument — Search for Exospheric Refilling and Emitted Natural Abundances (SERENA) — onboard BepiColombo. BepiColombo is a joint mission between the European Space Agency (ESA) and the Japan Aerospace Exploration Agency (JAXA), executed under ESA leadership. The mission comprises two spacecraft: the Mercury Planetary Orbiter (MPO) and the Mercury Magnetospheric Orbiter (MMO, now named Mio). The overall cost of the BepiColombo mission is more than 3 billion euros (€3bn).

SERENA has four units of complementary neutral and ionized particle detectors. It will provide information on the whole surface-exosphere-magnetosphere coupled system and the processes involved, plus the interactions between energetic particles, the solar wind, micrometeorites and the interplanetary medium. Specifically, STROFIO (STart from a ROtating Field mass spectrOmeter) measures in-situ the lower-energies neutral particle composition and density in the exosphere; ELENA (Emitted Low-Energy Neutral Atoms) covers the higher energy spectrum of neutral particles released from the surface; MIPA (Miniature Ion Precipitation Analyser) will monitor the solar wind, and PICAM (Planetary Ion CAMera) is optimized to measure low-energies planetary ions.

C. Dong is also a team member of NASA's Mars Atmosphere and Volatile Evolution (MAVEN) mission, and a member of the NASA's Parker Solar Probe (PSP) Venus Working Group.

TRANSP (F. Poli):

The annual TRANSP users group meeting was held at the DPP-APS meeting on Oct. 22 in Fort Lauderdale, Florida. F. Poli met users to discuss the latest development of the code and to take requests and feedback. A poster on the status and plans for TRANSP was presented, as part of the NSTX-U poster session.

COMMUNICATIONS & PUBLIC OUTREACH (A. ZWICKER)

Communications (L. Bernard):

The Office of Communications posted two news stories to the PPPL website. The first focused on prestigious awards recently given to two post-doctoral researchers at PPPL. The honors, the 2019 Christiaan Huygens Science Award for physicist C. Smiet and the 2019 Under 30 Scientist and Student Award for physicist R. Mukherjee, recognize exceptional contributions by the two scientists at the start of their careers. The second story focused on the passing of J. Manickam, a physicist at PPPL for 36 years who was

head of the Theory Division and collaborated on physics experiments around the world. These stories were also posted on the *Newswise* press release distribution service.

DIRECTOR'S OFFICE (S. COWLEY)

S. Cowley, J. Menard and M. Zarnstorff participated in the annual American Physical Society (APS) Division of Plasma Physics (DPP) meeting, held in Fort Lauderdale, Florida, Oct. 21-25. Menard presented a poster entitled, "Scoping studies for a sustained high-power-density next-step tokamak facility," and M. Zarnstorff presented a poster entitled, "Simple-coil optimized stellarator designs for pilot plants."

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