Weekly HIGHLIGHTS

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

The PPPL Highlights for the week ending June 16, 2018, are as follows:

NSTX-U RECOVERY AND RESEARCH (J. MENARD)

Recovery:

The NSTX-U recovery project completed a two-day risk workshop. During the workshop, which was facilitated by K. Molenaar from the University of Colorado at Boulder, the project team identified approximately 300 risks and developed risk statements to be incorporated in the project risk registry.

The plasma-facing component (PFC) recovery team successfully held a material selection review meeting on June 15. The meeting reviewed the choice of material for high heat flux and low heat flux components and recommended a strategy to meet project goals.

For the inner poloidal field (PF) coils, electrical testing was successfully completed on the first vendor-fabricated prototype coil. This testing will be followed up by destructive testing and analysis.

Research:

M. Iafrati of ENEA, C.R. Frascati, Italy visited NSTX-U during the week of June 11. He also visited other PPPL facilities including NSTX-U, LTX, and liquid-metal-related facilities, and met with a number of PPPL researchers associated with liquid metal research.

U.S. ITER FABRICATION (H. NEILSON)

Subcontractor Nova Photonics reported that they have installed a high-resolution spectrometer on their mirror cleaning apparatus to monitor aluminum emission lines during a cleaning cycle. In the previous month it was determined that this spectrometer has sufficient resolution to distinguish close-lying aluminum and argon neutral emission lines. Unmagnetized argon plasmas were operated at 100 W and 5 mTorr for approximately 75 minutes. These conditions produced a self-bias of 330 V on the mirror and resulted in sputtering rates of approximately 80 nm/hr for stainless steel and 45 nm/hr for aluminum on aluminum oxide. These sputtering rates are comparable to what was found for neon plasmas and aluminum on stainless steel, but with 440 V self-bias. A comparison of cross-section measurements of the mirror in the coated and cleaned conditions showed very little asymmetry in the cleaning without magnetic fields.

ADVANCED PROJECTS (H. NEILSON)

Stellarators (D. Gates):

Recent upgrades to the stellarator optimization code STELOPT are allowing it to scale to larger computational infrastructures. In a recent test of the code, more than 20,000 cores were utilized on the Cobra supercomputer located at the Max Planck Computing and Data Facility in Garching, Germany. In this test, a low-aspect-ratio, two-field-period stellarator was optimized for quasi-poloidal symmetry and rotational transform characteristics. A differential evolution algorithm was employed utilizing a population of over 1,000 members, each with 75 unique genes describing the equilibrium. The Intel Xeon Skylake-based cluster took under two hours to evaluate 12 generations, over 12,000 VMEC equilibria. Similar capabilities are being tested on the NERSC Cori computer. In those simulations, collisionless energetic particle confinement simulations are being included in the optimizations.

D. Gates visited the National Institute for Fusion Science in Toki, Japan, June 11-15. The purpose of the visit was to develop plans for PPPL collaborations on the Large Helical Device (LHD) for the coming years. Gates met with several members of the LHD scientific staff as well as the LHD management to discuss research opportunities. Several areas were identified that may lead to collaborations and draft task agreements were discussed. The topics for collaboration ranged from experimental proposals to diagnostic development to future device design. Specific collaboration topics were identified for future discussions and key personnel were identified to carry out the planning for these opportunities.

System Studies (C. Kessel):

H. Neilson attended the U.S.-China Fusion Collaboration Workshop June 5-7 in Xi'an, China. The workshop featured presentations by attendees from both sides on joint activities, clearly showing the productivity of collaborations between the two countries in a range of topics. A presentation by J. Li of the Institute of Plasma Physics, Chinese Academy of Sciences, described the design of the China Fusion Engineering Test Reactor (CFETR) and acknowledged contributions of teams from General Atomics and PPPL in the work to date. The project recently received authorization to proceed with engineering design, based on a concept intended to generate 1,000 megawatts of fusion power for pulse lengths of eight hours or more, and to generate net electricity and breed tritium. Li invited continued collaboration by U.S. researchers and identified several physics and engineering topics of particular importance for future collaboration.

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THEORY (A. BHATTACHARJEE):

In honor of R. Kulsrud's 90th birthday, *Physics of Plasmas* has made some of his papers free to download for a limited time: https://aip-info.org/1XPS-5NVR6-B8KCNCOGC1/cr.aspx Kulsrud began his research as a theoretical physicist on Project Matterhorn in 1954. During his long career at PPPL and at Princeton University, Kulsrud has written numerous articles with pioneering contributions to the field. In 1993, Kulsrud received the James Clerk Maxwell Prize for "his pioneering contributions to basic plasma theory, to the physics of magnetically confined plasmas, and to plasma astrophysics."

I. Dodin presented an invited talk at the SIAM Conference on Nonlinear Waves and Coherent Structures in Orange, CA. The talk was titled, "Inhomogeneous Wave Turbulence as an Effective Quantum Plasma: A Study of Zonal Flows." The underlying work, which is largely covered by a recent paper [*Phys. Rev. E* **97**, 053210 (2018)], was done in collaboration with H. Zhu, Y. Zhou, and D. Ruiz (Sandia National Laboratory).

M. Landreman, at the University of Maryland, presented a theory department seminar titled, "Computing local sensitivity and tolerances for stellarators using shape gradients." The abstract and a copy of the presentation are available on the Theory Website.

R. Dewar, from the Australian National University, visited the theory department June 11-15 to continue his collaboration with various members of staff.

COMMUNICATIONS AND PUBLIC OUTREACH (A. ZWICKER)

COMMUNICATIONS (L. BERNARD)

The Office of Communications posted one press release to the PPPL website. It focused on Steven Cowley, the newly named PPPL director, receiving a knighthood from Queen Elizabeth for "services to science and the development of nuclear fusion." The story was posted to the Newswise press release distribution service and it ran on the Princeton University home page.

SCIENCE EDUCATION (A. ZWICKER)

The week of June 11-15, the Science Education Department hosted the introductory course in plasma physics given to the incoming summer Science Undergraduate Laboratory Internships (SULI) students. The students attended 16 introductory lectures on many topics of plasma physics and fusion, as well as participated in an experimental session, a tour of the lab and homework sessions — problem sets in physics — led by

graduate students. The full schedule and list of speakers can be found here: https://suli.pppl.gov/2018/course/

DIRECTOR'S OFFICE (R. HAWRYLUK)

On June 13, B. Jorns, from the University of Michigan, presented a colloquium titled, "High Power Electric Propulsion for the Next Generation of Space Exploration."

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