# Weekly HIGHLIGHTS

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

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

**NSTX-U RECOVERY (R. HAWRYLUK) AND RESEARCH (J. MENARD)**

*Recovery:*

**Engineering** — The CMG shop reduced dimensional deviations and additional imperfections on the center stack bellows. The bellows is a critical item for the center stack because it takes various loads and is a vacuum boundary component. The CMG shop also completed prototypes of T-bars, OBD tiles 2, 3, and 4, and associated shear pins. The next round of T-bar prototypes will be made after creation of the revised model. The weld fixtures for the slings are underway and will be completed early next week. The weld fixtures are an important component of sling construction because they provide dimensional control of the joint.

**Magnets** — Poloidal-field (PF) production coil procurement evaluation was completed last week and is undergoing management review. The first set of G11 coil spacers will be delivered on April 30. The issues around the tolerances and surface finish of the mandrel wedge have been resolved, and delivery of the first set of mandrel wedges is due on April 10. Two of the PF1a conductors will ship via air freight from ICAS Tratos in Italy and arrive at PPPL around March 23. The PF1a, PF1b, and PF1c conductor spares are expected to arrive around April 10. There is a hold on production of the PF1b and PF1c conductors for direct shipment to vendors. The first draft of the coil winding procedure was completed and is under review.

In support of the toroidal field (TF) torsional and tensile effects work-scope, several meetings were held reviewing the analysis of the TF bundle and identifying the need for further analysis and test data. A draft specification of work was prepared and is undergoing review.

*Research:*

**Collaborations** — M. Podesta visited CCFE (Culham, UK) the week of March 3 and discussed plans for collaborations on energetic particle physics between MAST-U and NSTX-U. In particular, possible MAST/MAST-U targets for validation of reduced energetic particle transport models developed by PPPL were identified, including discharges with kinks and fishbones. M. Podesta and F. Poli also visited Tokamak Energy and met with O. Asunta, S. McNamara and P. Buxton to discuss modeling ST-40 plasma discharges with TRANSP in support of parameter scans for stability analysis, confinement studies, and for an assessment of the expected unstable spectrum of Alfvénic instabilities.

S. Sabbagh and M. Ono hosted J.-G. Bak and H.-S. Kim from the National Fusion Research Institute in South Korea this week for meetings regarding several classes of magnetic sensors on NSTX-U and progress on real-time MHD analysis for KSTAR. Their visit included a tour of NSTX-U given by S. Gerhardt. Several meetings with S. Sabbagh, S. Gerhardt, and E. Fredrickson satisfied the goals of the first topic. Sabbagh, W. Que, and K. Erickson displayed and gave some initial demonstrations of the new real-time MHD analysis computer and KSTAR diagnostics interface chassis to the visitors. The system is targeted for installation at NFRI later this year as part of an international collaboration on disruption prediction and avoidance.

**Publications** — The paper titled, "Application of Transient CHI Plasma Startup to Future ST and AT Devices," by K. Hammond, R. Raman, and S. Jardin was published online in Physics of Plasmas: https://aip.scitation.org/doi/full/10.1063/1.5087259. The paper is based on an invited talk given by K. Hammond (Columbia University / IPP–Greifswald) at the 2018 APS-DPP conference. The paper compares the conditions for coaxial helicity injection (CHI) discharge initiation with two electrode configurations: one that was implemented in HIT-II and NSTX, and another that is less extensively tested to date but would be easier to implement in reactors.

**U.S. ITER FABRICATION (H. NEILSON)**

A key challenge for designing the ITER Low-Field-Side Reflectometer (LFSR) is ensuring compatibility with required remote-handling operations. The LFSR in-vessel antenna assembly will be installed in one of the diagnostic shield modules (DSM) in Equatorial Port 11. The PPPL team is investigating design solutions that would allow removal of the LFSR equipment from the DSM by remote handling if necessary. A remote handling mockup facility being planned by the ITER Organization can support the design development through testing of remote handling designs and operations. The LFSR team provided comments on the functional requirements for this facility, focusing on generic requirements, shielding sub-modules, cooling water, and LFSR interface details. The potential benefits to the LFSR of ITER's mockup plans continue to be evaluated.

The final report of the recent design review for the LFSR Reflection Mockup article was approved and issued; fabrication in PPPL shops is now under way. In addition, a weld block mockup is being prepared for machining followed by proof-of-concept tests for weld details required by ITER. A prototype LFSR antenna front end, which will be used to test ideas for improved fabricability, is in the planning and awaiting materials delivery.

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**ITER & TOKAMAKS (R. NAZIKIAN)**

**DIII-D (B. Grierson):**

*Research:*

A new public release of the Generalized Perturbed Equilibrium Code (GPEC) [doi:10.11578/GPEC/dc.20190207.1.] was released this week. The GPEC package now includes the State Transition Rapid Integration with DCON (Asymptotic) Expansions (STRIDE) code, which can calculate the ideal MHD stability in 100s of ms using parallel state transition matrix integrations. It also provides ideal external delta-prime, which has been benchmarked against resistive DCON (also included in the GPEC package). The public releases of this code are maintained and used at the PPPL, DIII-D National Fusion Facility, NFRI, and IPPMPG laboratories.

N. Logan attended the fifth week-long OMFIT developers code camp held at General Atomics. He worked closely with NFRI researchers M. Lee and J. Kang and produced the first kinetic equilibrium reconstructions of KSTAR generated using the OMFIT workflow coupling EFIT, OMFIT profiles, and TRANSP. This is the culmination of an actively pursued collaboration effort between KSTAR and the PPPL TRANSP team, which established the fundamental connection between KSTAR and TRANSP. The OMFIT workflow manager provides an accessibility to the powerful PPPL tools that is consistent across domestic and international tokamaks and will be used to increase productivity in KSTAR data analysis and predictive optimization.

**ADVANCED PROJECTS (D. GATES)**

**Stellarators (D. Gates)**

The Laboratory's Plant Instrumentation and Controls group reported progress in its work supporting the Wendelstein 7-X (W7-X) Continuous Pellet Fueling System project. A Compact DAQ (data acquisition) device, which will be used to support software development for the pellet injector, has been received from the supplier, National Instruments. The device will be configured and programmed to emulate the functions of the pellet injector currently being designed by the Oak Ridge National Laboratory pellet group. The emulator will mimic the operation of the injector, enabling the Laboratory to develop the control software, a key PPPL responsibility under the pellet injector collaboration. In addition, the W7-X team has made its CAD software for electrical drawings available to PPPL. This will make it possible for PPPL to develop drawings in the format compatible with the W7-X CAD database, avoiding conversion issues. This week the CAD software was accessed remotely from PPPL for the first time, and a few file and drawing operations were completed in a successful test.

On March 4, S. Lazerson was hosted by L. Shao at the Texas A&M University Ions and Materials Facility. The purpose of the visit was to test a prototype fast-ion-loss detector under development for W7-X. The prototype detector was installed in the 140 kV linear accelerator operated by graduate student T. Wang. The detector performed as expected with measured signals consistent with the beam line current. While scans of the beam-line energy and current are still under analysis, initial data suggests the prototype sensor was behaving as expected. Specifically, the top sensor layer was measuring the floating potential of the vacuum/beam environment while the other layers were measuring only the beam energy. These results are promising and suggest future avenues of diagnostic development.

**THEORY (S. HUDSON)**

J. Sachdev attended the SIAM CSE Conference from Feb. 25-March 1 in Spokane, WA. He presented a poster on behalf of the TRANSP development team as part of the minisymposterium session on Software Productivity and Sustainability for CSE and Data Science. The title of the poster was, “Modernizing the Scientific Software Approach for the Fusion Analysis Code TRANSP.”

The paper titled, “Near-singular equilibrium currents near magnetic islands with broken symmetry,” by A. Reiman and D. Radhakrishnan has been accepted for publication in *Nuclear Fusion*: https://doi.org/10.1088/1741-4326/ab0968. This paper presents an investigation of the pressure-driven current near a small magnetic island in a cylindrical magnetic field with perturbed circular flux surfaces.

H. Qin’s paper titled, “Kelvin-Helmholtz instability is the result of parity-time symmetry breaking,” was published this week in *Physics of Plasmas*: https://aip.scitation.org/doi/10.1063/1.5088498. Using the example of the familiar Kelvin-Helmholtz instability, the paper demonstrates that classical conservative systems governed by Newton's law admit PT-symmetry, and the spontaneous breaking thereof is a generic mechanism for classical instabilities.

J. TenBarge’s paper titled, “Temperature-dependent saturation of Weibel-type instabilities in counter-streaming plasmas," by Skoutnev et al. was published in *Astrophysical Journal Letters*: https://iopscience.iop.org/article/10.3847/2041-8213/ab0556. In this paper, the authors present the first 2X2V continuum Vlasov–Maxwell simulations of interpenetrating, unmagnetized plasmas to study the competition between two-stream, oblique, and filamentation modes in the weakly relativistic regime.

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**SITE PROTECTION (M. SONNE)**

ESU completed Duress Alarm training, and Engine 66 responded to two mutual aid assignments in Plainsboro Township.

**This report is also available on the following web site:**

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