



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

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

#### *Recovery:*

**Magnets** — The DOE review of the production coil procurement package is complete, and the package is being prepared to go out for bid. The G11 coil spacer requisition has gone out for quote and mandrel wedges are in procurement. The conductor feed spool is being modified. Four out of five PF1C conductors have been grit-blasted and primed at ICAS Tratos, and a contracted QA inspector will replace magnet team members next week. Coil-testing chit resolution and design-approval sign-off is complete.

#### *Research:*

**Collaborations** — A. Diallo presented, "Introduction to H-mode Plasmas: L-H Transition, Pedestal, ELMs, and Stationary and Transient Power Fluxes," on Jan. 21 in Daejeon, South Korea, at the 10th ITER International School. The subject for the 10th IIS was the physics and technology of power flux handling in tokamaks. Diallo also gave a seminar titled, "Energy Exchange Dynamics Across the LH Transition in NSTX," at the National Fusion Research Institute (NFRI) while in South Korea.

R. Maingi presented two seminars at the Southwest Institute of Physics in Chengdu, China: "Real-time Impurity Injection for Wall Conditioning, ELM and H-mode Pedestal Control, and Divertor Exhaust Enhancement," and "The Nearly Continuous Improvement of Discharge Characteristics and Edge Stability with Increasing Lithium Coatings in NSTX." In the first seminar, technical details of flexible impurity dropper developed at PPPL were given, along with initial observations from wall conditioning and power exhaust experiments on ASDEX-Upgrade, DIII-D, EAST, and KSTAR. In the second seminar, ELM suppression and confinement improvement observations on NSTX with lithium wall coatings were presented, along with detailed analysis of recycling, transport, ELM macro-stability and micro-stability with the SOLPS, GS2, and ELITE code packages. The talks were used as the basis for discussions of potential new collaborations on impurity powder injection and lithium wall conditioning on HL-2A and HL-2M.

R. Raman, S. Jardin, and M. Ono worked with K. Kuroda (QUEST, Kyushu University, Japan) on TSC simulations during his visit to PPPL Jan. 7 to 25 as part of US-Japan Collaboration activity. This was in preparation for the next CHI campaign on QUEST. Simulations compared the previous CHI configuration used on QUEST during the December 2018 campaign to a new configuration that will drive current between the CHI electrode and the center stack of QUEST, as in NSTX. The simulations indicated that



dynamically shaping the injector flux would increase the closed flux current in these discharges.

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

A revision to the document, “Low Field Side Reflectometer (LFSR) Safety Barrier Design Report,” has been issued for comment by LFSR subcontractor General Atomics. The report deals with important engineered safety features of the LFSR design, which includes 50-meter-long waveguide runs that transmit microwave signals between the plasma-facing launchers in the tokamak and signal-processing electronics in the diagnostic building. Outside the tokamak, the waveguides pass through penetrations in walls that separate different fire zones in the complex. Each penetration includes a “safety barrier” that is designed to permit microwave transmission with minimal signal loss during operation while withstanding a pressure differential between zones. The design includes a shutter mechanism that can close the transmission lines to protect workers against microwave radiation exposure during maintenance operations and to isolate the fire zones from one another in emergency scenarios. The report describes modifications to the design and operating logic in response to Category 1 chits that were raised at the Nov. 2018 preliminary design review, pointing out some gaps in the protection functions. With contributions from PPPL engineer M. Sibilias, the design and documentation were revised to resolve these concerns. The revisions will be discussed with Central Team safety experts during an upcoming team visit to the project site, before being formally submitted.

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

PPPL participated in an interesting and productive SciDAC ISEP Project Meeting and EP Workshop hosted by lead principal investigator Z. Lin, held at UC Irvine on Jan. 23-24. PPPL participants included ISEP PAC (Program Advisory Committee) Chair R. Nazikian, ISEP Co-PI N. Gorelenkov, and ISEP Co-PI B. Tang, who gave a talk encouraged by PAC member T. Williams titled, “Integration of HPC (using the GTC Exascale Code) with Deep Learning Workflows (using the FRNN AI/Deep Learning Code).” In addition, J. Lestz presented a talk on hybrid simulations and theory of sub-cyclotron compressional and global Alfvén eigenmodes in NSTX.

#### **ADVANCED PROJECTS (D. GATES)**

##### **Stellarators (D. Gates):**

C. Zhu attended the Maryland-PPPL theory discussions on Jan. 22th and gave a talk titled, “Error field sensitivity analysis for modular coils of CFQS stellarator.” He

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introduced a new method to identify possible coil deviations that break the quasi-symmetry of the desired magnetic field. He applied this method on the CFQS stellarator, which is a quasi-axisymmetric stellarator under construction in China. The results will help the CFQS team avoid the most dangerous coil deviations and improve coil designs toward better quasi-symmetry.

E. Gilson and R. Lunsford were at the National Institute for Fusion Science Jan. 21-25 to finalize the physics and engineering requirements for installation of an impurity powder dropper (IPD) on LHD for experiments during the Fall 2019 campaign. Gilson made a brief IPD presentation at a small-group informal seminar and meetings were held with the NIFS data acquisition, CAD, and engineering teams to discuss the IPD installation. Gilson and Lunsford had regular consultations with A. Nagy at DIII-D, who could not make this trip, about site specific interface details. Installation of the powder dropper is planned for July 2019.

The W7-X Continuous Pellet Fueling System (CPFS) is proceeding on multiple fronts, with all partners making good progress in their respective responsibilities. The Oak Ridge National Laboratory (ORNL) team has completed the design of a prototype extruder, the device that feeds a continuous filament of cryogenic hydrogen into the injector mechanism. The prototype will be used to test the use of cryocooler technology to cool the incoming gas to cryogenic temperatures and the performance of a twin screw extruder to push the material through a 3-millimeter nozzle. Procurement of the main components is under way, and some have already been received. The Max Planck Institute for Plasma Physics (IPP) team has received proposals from major vacuum equipment manufacturers to supply the large pumps required to continuously exhaust waste hydrogen and helium propellant gas. At PPPL, a general requirements document for the CPFS control system is being developed by engineer P. Sichta to guide the instrumentation and control system integration for the project. Procurement preparations for a programmable logic controller system and associated software are under way. This system will initially be used for learning and software development and later will be enhanced to serve as the main control system for the CPFS. Finally, the National Institute for Fusion Science (NIFS) team reported that the second of two NIFS-supplied cryocoolers has been ordered and is due to be shipped to ORNL in March. Overall, the project is on track for a preliminary design review later this year.



## **THEORY (S. HUDSON)**

A. Reiman and N. Fisch had an opinion piece on their recent work published by *Newsweek.com*:

<https://www.newsweek.com/nuclear-fusion-clean-energy-unlimited-plasma-hotter-sun-unstable-1291871>

The work was favorably covered in two articles in *Forbes*:

<https://forbes.com/sites/arielcohen/2019/01/14/is-fusion-power-within-our-grasp/#5dff9abc7f36>

<https://www.forbes.com/sites/ellistalton/2019/01/14/energy-leaders-need-to-pay-more-attention-to-fusion-in-2019/>

and it was covered in the Russian press:

<https://lenta.ru/news/2019/01/10/plasma/>

It also received coverage on popularized physics websites, and was the top story in the *Science X* website's roundup of the best science stories of the last week:

<https://sciencex.com/news/2019-01-week-stabilizing-fusion-plasmas-privacy.html>

The Theory Department hosted an informal discussion on stellarator and other theory topics with participants from the University of Maryland. The discussion included B. Dorland, M. Landreman, A. Hassam, a remote presentation by T. Antonsen, graduate and undergraduate students, and many PPPL staff. There were 20 short presentations in total, and lots of physics discussions. Topics included areas of existing Maryland-PPPL collaborations, such as stellarator studies and the Multiscale Gyrokinetics SciDAC, as well as methods to generate quasisymmetric stellarator configurations, adjoint methods for stellarator optimization, the stellarator capabilities in XGC, GTS gyrokinetic studies of neoclassical effects and turbulence, MHD studies of ELMs and RMPs, Gkeyll simulations of edge turbulence and first results with electromagnetic extensions, fast multifidelity gyrokinetic algorithm development, and efficient mathematical models for simulating key edge physics processes.

Future informal workshops like this are in planning and will likely be extended to additional institutions.

N. Ferraro visited General Atomics Jan. 14-18 to meet with T. Evans, C. Paz-Soldan, O. Meneghini, E. Belli, M. Fenstermacher, and others to discuss plans for his RMP ELM

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mitigation project. He presented these plans at the DIII-D ELM suppression task force meeting. Ferraro also met with B. Lyons and P. Parks to discuss ongoing disruption mitigation modeling, and with S. Diem to discuss ELM pellet pacing simulations using M3D-C1.

N. Gorelenkov and V. Duarte presented talks at the 2nd Annual ISEP Meeting at the University of California, Irvine, Jan. 23-24. The titles of the presentations at the ISEP SCiDAC Meeting are “Towards 2D resonance broadened quasi-linear (QL) model (RBQ) for fast ion relaxation” (Gorelenkov) and “Collisional scattering effects on the quasilinear dynamics of Alfvénic eigenmodes” (Duarte).

A paper by V. Duarte and N. Gorelenkov titled, “Analytical nonlinear collisional dynamics of near-threshold eigenmodes,” was published in *Nuclear Fusion*: <http://iopscience.iop.org/article/10.1088/1741-4326/ab0135>

Members of the theory department attended the 2019 Annual ECP Meeting in Houston, Texas. C.S. Chang gave a poster presentation titled, “WDMApp: High-Fidelity Whole Device Model of Magnetically Confined Fusion Plasma,” and A. Scheinberg gave a poster presentation titled, “CoPA: Co-Design Center for Particle Applications.”

## PLASMA SCIENCE & TECHNOLOGY (P. EFTHIMION)

**LTX-Beta (R. Majeski):** A team including staff from the University of Wisconsin Department of Physics, LTX-beta and the neutral beam group has succeeded in operating the new neutral beam source now installed on LTX-beta to a power level somewhat exceeding 500 kW, for the full 5 millisecond pulse available from the power supply. Although the beam has not yet been injected into a tokamak discharge, this is an important step toward LTX-beta’s full, upgraded operation.

The PS&T astrophysics division had two major publications this month. First, a paper by D. Hung, K. Caspary, E. Gilson, and H. Ji, among others, titled, “Experimental confirmation of the standard magnetorotational instability mechanism with a spring-mass analogue” was published in *Communications Physics*. The paper reports an unambiguous laboratory demonstration of the spring-mass analogue to the standard magnetorotational instability by comparing motion of a spring-tethered ball within different rotating flows. Second, a paper by J. Jara-Almonte, H. Ji, J. Yoo, M. Yamada, and W. Fox titled, “Kinetic simulations of magnetic reconnection in partially ionized plasmas,” was published in *Physical Review Letters*. The paper presents the first fully kinetic particle-in-cell simulations of partially ionized reconnection and demonstrates that fast reconnection can occur in partially ionized systems.



## **INFORMATION TECHNOLOGY (M. COHEN)**

A paper by P. Bisbal titled, "Training Computational Scientists to Build and Package Open-Source Software," was published in a special issue of *The Journal of Computational Science Education* dedicated to HPC training and education: <http://jocse.org/currentIssue/>

## **SITE PROTECTION (M. SONNE)**

ESU staff completed their annual confined space training/entry drill. Engine 66 responded to three mutual aid assignments in Princeton Township and Ambulance 166 responded to four mutual aid assignments in Plainsboro Township.

## **COMMUNICATIONS & PUBLIC OUTREACH (A. ZWICKER)**

### **Communications (L. Bernard):**

The Office of Communications posted two press releases on the PPPL website. The first focused on the Lab's Remote Glow Discharge Experiment (RGDX) being named one of the 25 most-interesting webcams of 2018 by EarthCam.com, a website that collects webcams from thousands of sites across the globe and has been seen by 3.6 million viewers over the past six months. Judges from *USA Today*, *CBS News*, and elsewhere voted on "the most unique and interesting webcams of 2018" and ranked the RGDX in the top 25. You can find RGDX and the rest of the awardees here:

<https://www.earthcam.com/top25/2018/>

The second story dealt with research by R. Raman, J. Menard, and M. Ono into developing an electromagnetic particle injector, a type of rail gun that fires a high-velocity projectile from a pair of electrified rails into a plasma on the verge of disruption. The projectile, called a sabot, releases a payload of material into the center of the plasma that spreads out the energy stored in the plasma, reducing its impact on the interior of the tokamak.

Both stories were also posted on the *EurekaAlert* and *Newswise* press release distributions service.

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

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