

PRINCETON PLASMA PHYSICS LABORATORY

**WEEKLY** highlights



**The PPPL Highlights for the week ending May 22, 2015, are as follows:**

**NSTX (M. ONO):**

N. Bertelli, J. Hosea, R. Perkins and G. Taylor of PPPL attended the Topical Conference on RF Power in Plasmas that was held at Lake Arrowhead, California on April 27-29. Bertelli presented an invited talk entitled “Effect of the Scrape-Off Layer in AORSA Full Wave Simulations of Fast Wave Minority, Mid/High Harmonic, and Helicon Heating Regimes”. Perkins presented a poster paper entitled “High Voltage Test-Stand Research Done on ICRF Antenna Elements of the High-Harmonic Fast-Wave System of NSTX”, and Taylor presented a poster paper entitled “Development of Fully Non-Inductive Plasmas Heated by Medium and High-Harmonic Fast Waves in NSTX-U”. Bertelli, Hosea, Perkins and Taylor also participated in the U.S.-Japan RF Physics Workshop that immediately followed the RF Conference. The focus of the workshop was to encourage future collaborations between the U.S. and Japan RF research programs. The agenda for the session included short presentations by Japanese and U.S. researchers on future plans, highlighting areas of possible collaboration. Perkins presented the status and plans for PPPL RF research and Joel Hosea coordinated the workshop agenda for the U.S. delegation. The meeting concluded with a discussion of the collaboration proposals.

Recovery from an external arc fault at the Ohmic Heating (OH) coil terminals continued this week. Inspections, tests, and analysis of the upper umbrella structures have been completed, and prototypes of redesigned components are being fit-up. The removal of the lower TF flex buses has been completed, and the lower OH lead extensions are being removed to provide access for inspections and rework. Electrostatic analysis of a new OH cooling tube bracket design has been completed and a prototype has been built. Electrical insulation tests (Hi-Pots) of this new design are now being performed on that prototype. Also this week, power testing of Field Coil Power Conversion (FCPC) rectifiers into a “dummy” load continued on additional TF parallels, and a run-up on the motor generator was successfully performed after the replacement of the cycloconverter transformer. Installation of components for the Purdue Material Analysis Particle Probe (MAPP) diagnostic is in progress.

**ITER & TOKAMAKS (R. HAWRYLUK):**

**DIII-D (R. Nazikian):**

G. Kramer attended the international reflectometer workshop from May 18-20, held in Juelich, Germany. He presented a talk titled "Simulation of the antenna-plasma coupling for the low-field side ITER reflectometer system" in which antenna coupling calculations with the 3D FWR3D

code were presented.

The optical fibers purchased by PPPL for the BES diagnostic was installed this week. These replace ~18 year old quartz fibers that were part of the original BES system installation. A team lead by A. Nagy completed the replacement in under three hours. The new fibers were checked after installation and are all fully functional.

A. Nagy authored a SOFE paper on "Operational Experience with the Lithium Granular Injector on DIII-D", to be submitted for publications in the conference proceedings.

A. Nagy is the lead engineer for the Super Spa patch panel, currently being designed to accommodate the enhanced power supplies that will be delivered to DIII-D from ASIPP. The panel is currently under design. The patch panel will enable the new bipolar power supplies to drive the C-coils, I-coils, and F-coils in conjunction with the existing SPA, C-supplies, and Audio Amplifiers. The old I-coil patch panel designed and built by Nagy in 2001 will be abandoned for this new improved version.

### **C-Mod (R. Hawryluk):**

The journal "Physics of Plasmas" has accepted for publication a paper entitled "Multispecies Density Peaking in Gyrokinetic Turbulence Simulations of Low Collisionality Alcator C-Mod Plasmas", by D. Mikkelsen and co-authors from PPPL and MIT. For most ion species, density peaking is found in nonlinear gyrokinetic turbulence simulations based on measured profile data from a low collisionality H-mode plasma in Alcator C-Mod. Hydrogenic density peaking has a very weak isotope dependence, but impurity density peaking depends on the species: weak peaking for helium, but increasingly more peaking for medium and high-Z impurities. The majority-species peaking is broadly consistent with the measured electron density peaking, but the profile shape differs in detail.

B. Mumgaard successfully defended his dissertation on Thursday, "Lower Hybrid Current Drive on Alcator C-Mod: Measurements with an Upgraded MSE Diagnostic and Comparisons to Simulation".

### **ADVANCED PROJECTS (H. NEILSON):**

D. Gates visited the Max Planck Institute for Plasma Physics (IPP) in Greifswald, Germany the week of May 18-22. The primary purpose of the visit was to discuss scheduling of the installation of the remaining components of the W7-X X-ray imaging crystal spectrometer (XICS) diagnostic. The XICS will provide high-resolution measurements of plasma temperature and velocity profiles. An installation plan outline was submitted to the W7-X Assembly team for review and a schedule, which would make the XICS available for the first operating campaign, OP1.1, was agreed upon. Accompanying Gates on this visit were Dr. Carlos Paz-Soldan (General Atomics) and Professor E. Kolemen (Princeton University, Mechanical and Aerospace Engineering), who participated in several meetings with IPP staff to discuss future research opportunities on W7-X. Both Professor Kolemen and Dr. Paz-Soldan gave research colloquia at IPP.

During a visit to the Chinese Academy of Sciences' Institute for Plasma Physics (ASIPP) in Hefei, China, T. Brown and H. Neilson discussed plans for research on next-step fusion devices under a Strategic Partnership Project (SPP) agreement between ASIPP and PPPL. ASIPP team members provided an update of recent progress in the analysis of magnets and breeding blankets for the China Fusion Engineering Test Reactor (CFETR), which has been proposed for construction starting around 2020. It was agreed that PPPL will contribute in the area of overall design integration under Brown's leadership. A plan to update CFETR component space allocations (the so-called radial build) was formulated. In addition it was agreed that PPPL will, at first, review and comment on ASIPP's blanket studies, which are documented in a detailed Design Description Document. Thereafter, it is expected that PPPL will carry out selected blanket engineering analysis tasks as needed. Finally, it is also planned that PPPL will carry out system code studies to support the choice of major tokamak and heating system parameters for CFETR.

The Laboratory hosted a visit by Dr. Louis Zani of CEA, Cadarache, France, magnet engineering leader for Europe's Power Plant Physics and Technology Program. Zani met with several members of the engineering staff to discuss opportunities for possible collaboration in the analysis of magnets for Europe's DEMO design studies. He also presented a seminar on the status of European Union DEMO magnet studies.

#### **PLASMA SCIENCE AND TECHNOLOGY (P. EFTHIMION):**

A paper has been published based on the MRX data, in the May issue of Phys. Plasmas entitled "Study of energy conversion and partitioning in the magnetic reconnection layer of a laboratory plasma" by M. Yamada, J. Yoo, J. Jara-Almonte, W. Daughton, H. Ji, R. Kulsrud, and C. Myers. Recently, we have reported results on the energy conversion and partitioning in a laboratory reconnection layer in a short communication [Yamada et al., Nat. Commun. 5, 4474 (2014)] paper. The present paper is a detailed elaboration of this report together with an additional dataset with different boundary sizes. We have observed that the conversion of magnetic energy occurs across a region significantly larger than the narrow electron diffusion region. A quantitative inventory of the converted energy is presented in a reconnection layer with a well-defined, variable boundary. We have also carried out a systematic study of the effects of boundary conditions on the energy inventory. This study concludes that about 50% of the inflowing magnetic energy is converted to particle energy, 2/3 of which is ultimately transferred to ions and 1/3 to electrons.

Yuanta Zhang from Shandong University, China gave PS&T seminar on "Theoretical and numerical study on the stability and reactivity of atmospheric plasmas". The abstract reads: "Non-equilibrium atmospheric plasmas have received growing attention in recent years for their economic and scientific potentials. Usually dozen of species with diverse lifetimes could be generated at atmospheric pressure and some reactive oxygen or nitrogen species with hundreds of chemical reactions involved play key roles in many applications. A critical challenge is the inherent difficulty of increasing plasma reactivity (for application efficiency) without compromising plasma stability (for process controllability). Modeling tools are developed to have a coherent understanding of the stability-reactivity relationship of atmospheric plasmas."

A paper "On filament structure and propagation within a commercial plasma globe," has been published online in *Physics of Plasmas* (Vol.22, Issue 5), and can be seen at: <http://scitation.aip.org/content/aip/journal/pop/22/5/10.1063/1.4919939> DOI: 10.1063/1.4919939. This paper is the result of an off-site University collaboration between C. Brunkhorst, A. Nagy, and S. Zweben of PPPL and Professor Michael Burin of Cal State San Marcos and his students. This paper investigates the discharge properties of a plasma globe using a variable high voltage amplifier. We find that increasing voltage magnitude increases the number of filaments while leaving their individual structure basically unchanged, a result typical of dielectric barrier discharges. At each voltage cycle the discharge expands outward at 10–15 km/s, a speed significantly higher than the estimated electron drift yet considerably lower than that observed for most streamers. We discuss the physics of these observations and their relation to similar discharges that can be found within nature and industry.

### **THEORY (A. BHATTACHARJEE):**

J. Breslau gave the Theory Department Research and Review Seminar entitled "Spline Representations for More Efficient Stellarator Coil Design" on May 22. The abstract reads "From an engineering perspective, the chief drawback of modern stellarator designs is the high complexity of their magnetic coils: they are challenging to wind, and encircle the device in a manner that impedes maintenance access. The substitution of modular coil systems with long straight outer legs supplemented by saddle coils could address both these problems. The commonly used Fourier representation of coil shapes within a winding surface does not easily lend itself to the design of straight coil sections. The new design tool COILOPT++ makes use of a cubic B-spline coil representation that offers several advantages over the Fourier model. In addition to allowing the straightforward joining of curved and straight sections with second-order continuity, the spline approach allows for more efficient and interactive optimization. I will present two applications of this code: demonstrating the practicality of the straight-outer-leg concept for a moderate-aspect-ratio configuration based on ARIES-CS; and attempting to design trim coils to reduce turbulent transport in QUASAR."

On May 14-15, L. Zakharov and D. Hu visited the Plasma Science Fusion Center of MIT in Cambridge, Massachusetts for discussion of vertical disruptions in the C-mod tokamak. This machine exhibits a large poloidal halo currents measured directly by special Rogowski Coil. Initially considered as exceptional, the value of these currents and its timing at the end of the disruptions now appear to be consistent with the theory consideration of the halo zone as a specific Scrape Off Layer, created by the plasma particles released from the shrinking core. The theory predicted source limitation of SoL currents is now consistent with their minor role in JET disruptions and significance in C-mod (at the end of disruptions).

On May 15, L. Zakharov gave a talk to PSFC on "Theory of tokamaks VDE and associated currents".

On May 21, Professor Xiaohua Deng of Nanchang University presented a joint heliocenter/theory seminar on space physics research in China and dynamics of Earth's magnetosphere. He briefly introduced the recent development and plan of space science in China, then discussed recent research on dynamics of Earth's magnetosphere, especially the structures, waves and particle acceleration during the process of reconnection and propagation of

dipolarization front in the magnetotail region. Finally, he mentioned the development and plan of space science and technology in Nanchang University.

## **ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):**

### **NSTX Upgrade (R. Strykowski, E. Perry, L. Dudek, T. Stevenson):**

CS: The disassembly of the lower umbrella was completed. Staff performed epoxy adhesive test on the OTF Finger supports. The parts went together easily and epoxy filled the gaps nicely. All parts were prepared with mold release before assembly. They were disassembled after epoxy was left to cure for several days and all parts were separated from the epoxy with minimum amount of effort. The test was considered successful. More epoxy was ordered to complete the shimming of all of the OTF fingers on the machine.

Drawings for the upper and lower OH water tube supports were completed and a successful design review was held on May 22. Drawing modifications for the OH preload assembly grounding and ground clamp continue.

NBI: Power supply repairs continued. N2A and N2C sources completed decel conditioning and high voltage was attempted. An FVI problem and a bending magnet power supply problem were discovered and troubleshooting was started. The BL1 pumpdown was halted due to suspected leaks. The BL was isolated and successfully passed rate-of-rise tests. The turbo molecular pump flange is therefore suspect and will be leak checked. The N1A source was found to have an internal water leak so it was removed. The OMA box and source were drained of contaminated water per HP procedures. The source has been moved to the Source Shop in the Mockup Building for drying and refurbishment. Source Shop activities included source repairs and area preparation in the Decontamination Room.

DCPS: The DCPS system was presented to the Extent of Condition Task Force in relation to the OH fault recovery. The DCPS system continues in service supporting ongoing dummy load rectifier tests.

## **BUSINESS OPERATIONS (K. FISCHER):**

First year funding in the amount of \$126,000 was received from NASA for the research proposal titled "An Investigation of Electron Acceleration and Energy Transport by Alfvén Waves in the Jovian Magnetosphere." The Principle Investigator for this effort is P. Damiano.

The U.S. Department of Agriculture provided funding in the amount of \$10,800 for the research proposal titled "USDA Applications of the Sterilization of Foods." The Principle Investigator for this effort is C. Brunkhorst and the period of performance is seven months.

Princeton University provided second year funding in the amount of \$70,000 for the Strategic Partnership Projects Agreement titled "Fundamental Studies of Reactive Processes at Plasma-Surface Interfaces." The Principal investigator for this effort is Y. Raitses.

PPPL submitted a Project Data Sheet for a new Laboratory Directed Research and Development (LDRD) project to the DOE for concurrence. The project is titled "Scoping Study for a World-Leading U.S. Stellarator Program and Facility". Including the budget requested for this project, the total budget allocated to LDRD projects in FY15 is \$2.7 million against the \$3.0 million LDRD funding ceiling approved by DOE.

PPPL submitted a proposal to the DOE Office of Fusion Energy Sciences entitled "Plasma Science Studies of High Pressure Arc-Plasma Nanomaterial Synthesis". The requested budget for the three-year period of performance is \$2.6 million and the Principal Investigator is I. Kaganovich.

#### **ENVIRONMENT, SAFETY, & HEALTH (J. LEVINE):**

An audit of State certified environmental analyses performed in the PEARL was conducted by the NJ Department of Environmental Protection.

#### **DIRECTOR'S OFFICE (C. AUSTIN):**

On May 12, Professor Luis Silva, Department of Physics, Instituto Superior Técnico, presented a colloquium entitled, "In Silico Plasmas Under Extreme Intensities".

May 13-14, the bi-annual PPPL Advisory Committee was held at PPPL. The purpose of the PPPL Advisory Committee is to review the efficiency and effectiveness of the Laboratory science and operations.

Former N.J. Governor Christine Todd Whitman visited PPPL on May 18 with members of The American Security Project. Governor Whitman is the chairperson of their board. ASP is very interested in fusion energy - they received a briefing regarding fusion and the Laboratory. Director Prager conducted the briefing, followed by a tour of the facility.

On May 20, Department of Energy Deputy Secretary, Dr. Elizabeth Sherwood-Randall visited PPPL. She met with Princeton Site Office and PPPL management, was given a tour of the Laboratory, and addressed staff at an "all hands" meeting.

On May 20, Professor David J. Callans, M.D., Hospital of the University of Pennsylvania, presented a colloquium entitled, "The Electrical System of the Heart".

#### **INVITED TALKS:**

Bertelli, N., "Effect of the Scrape-Off Layer in AORSA Full Wave Simulations of Fast Wave Minority, Mid/High Harmonic, and Helicon Heating Regimes," Topical Conference on RF Power in Plasmas, Lake Arrowhead, California

## **PUBLICATIONS:**

Yamada, M.; Yoo, J.; Jara-Almonte, J.; Daughton, W.; Ji, H.; Kulsrud, R.; and Myers, C., "Study Of Energy Conversion And Partitioning In The Magnetic Reconnection Layer Of A Laboratory Plasma," Physics of Plasmas 22, 056501

Burin\*, M.J.; Simmons, G.G.; Ceja, H.G.; Zweben, S.J.; Nagy, A.; and Brunkhorst, C., "On Filament Structure And Propagation Within A Commercial Plasma Globe," Physics of Plasmas Vol.22, Issue 5,  
<http://scitation.aip.org/content/aip/journal/pop/22/5/10.1063/1.4919939> DOI:  
10.1063/1.4919939.

This report is also available on the following web site:

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