

PRINCETON PLASMA PHYSICS LABORATORY

**WEEKLY** highlights



**The PPPL Highlights for the week ending October 31, 2014, are as follows:**

### **U.S. ITER FABRICATION (D. JOHNSON):**

The Release for Shipment documentation has been approved by PPPL for delivery to ITER of one of three HV substation transformers from Hyundai Heavy Industries in Korea. Factory acceptance tests for two more such transformers are planned at Hyundai in early November.

The last two procurement arrangements governing US ITER diagnostics were signed. 5.5.P5.US.01 is for the Core Imaging X-ray Spectrometer, and 5.5.P6.US.01 governs Equatorial Port Plug 3 and the Motional Stark Effect diagnostic.

The US also signed an agreement to let the ITER Organization procure the two upper and two equatorial port plug structures from a common manufacturer that is building these structures for all diagnostic port plugs.

As the lead engineer for equatorial port plug 3, PPPL's K. Tresemer attended a technical meeting in Cadarache, France to meet with tenants of this plug, including designers of the Edge Charge Exchange Recombination Spectrometer diagnostic provided by the RF-DA and IO representatives of the Glow Discharge System.

At UCLA, a test run of transmission line designed for the frequency range envisioned for the ITER Low Field Side Reflectometer is being evaluated for losses at the low frequency end of this range.

### **NSTX (M. ONO):**

NSTX-U physicists attended the Annual APS-DPP meeting held in New Orleans, Louisiana on October 27-31. There were an ST review talk and five NSTX/NSTX-U related Invited Talks: M. Ono (PPPL) – “Recent progress on spherical torus research and implications for fusion energy development path”, Joon-Wook Ahn (ORNL) – “Broadening of the divertor heat flux footprint with increasing number of ELM filaments in NSTX”, Jeremy Lore (ORNL) – “Simulation of 3D effects on partially detached divertor conditions in NSTX and Alcator C-Mod”, Z.R. Wang (PPPL) – “Drift Kinetic Effects on 3D Plasma Response in High-beta Tokamak Resonant Field Amplification Experiments”, S.A. Sabbagh (Columbia U.) – “Unification of Kinetic Resistive Wall Mode Stabilization Physics in Tokamaks”, and E. Belova (PPPL) – “Energy Channeling and Coupling of Neutral-beam-driven Compressional Alfvén Eigenmodes to Kinetic Alfvén Waves in NSTX”. In addition, there were six NSTX/NSTX-U related oral contributed talks and

38 contributed posters.

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

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

PPPL researchers on the DIII-D collaboration attended the APS DPP meeting in New Orleans, Louisiana. B. Grierson presented an invited talk on low-Z impurity confinement in QH-mode and RMP ELM suppressed plasmas. He demonstrated with fluorine gas puffs that impurity confinement in both regimes is in the range of 2-3x the energy confinement, equivalent to H-mode plasmas with 20-40 Hz ELMs. A. Diallo presented an invited talk on the evolution of profiles and transport between ELMs in DIII-D and C-MOD plasmas. Analysis shows that an edge localized quasi-coherent mode is correlated with the evolution of the temperature profile in both devices. W. Solomon presented a contributed talk in the DIII-D session on the first access to Super H-mode confinement in QH-mode plasmas at high density. Analysis demonstrated that Super H-mode should be accessible on ITER. R. Hawryluk presented a contributed talk on the use of non-axisymmetric fields for burn control in a fusion reactor. Experiments on DIII-D demonstrated effective control of the plasma-stored energy using the I-coils, where the stored energy is used as a proxy for fusion power.

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

L. Delgado-Aparicio discussed locked-mode avoidance and recovery without external momentum input using ICRF. S. Scott discussed the scaling of lower hybrid wave efficiency in C-Mod. This was a companion poster to the invited talk by B. Mumgaard at the APS DPP meeting in New Orleans.

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

The Laboratory and Korea's National Fusion Research Institute (NFRI) continue to collaborate on a conceptual study for a next-step fusion nuclear facility, K-DEMO. In a October 27 videoconference meeting, PPPL's P. Titus reported progress on a numerical simulation of a vertical displacement event (VDE) disruption. A finite-element model of the machine's conducting structures, including the magnet system, vacuum vessel, and in-vessel blanket system, has been developed. Toroidal and poloidal field coil currents from a steady-state, full power equilibrium condition are used to generate the external magnetic field, while the plasma is represented by a finite-element model that allows for vertical drift and a rapid quench of the current. Induced currents and the resulting Lorenz forces in the various structures are calculated; as expected the largest effects are seen on components closest to the plasma, namely the blanket modules and their support shell. Results from these simulations will be used to guide the design of affected structures during the next phase of the study, which is scheduled to begin next March.

D. Gates, S. Lazerson, N. Pablant, R. Goldston, and C. Kessel all presented posters and/or oral presentations at the Annual meeting of the APS-DPP which was held in New Orleans, Louisiana from October 27-31.

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

Many researchers from the PPPL Theory Department attended the Annual Meeting of APS Division of Plasma Physics in New Orleans, Louisiana, November 27-31. There were several invited talks given by Department members: E. Belova gave talk titled "Energy Channeling and Coupling of Neutral-beam-driven Compressional Alfvén Eigenmodes to Kinetic Alfvén Waves in NSTX", M. R. Churchill gave talk titled "Poloidal Asymmetries in Edge Transport Barrier", I. Dodin gave an invited talk, "The ponderomotive effect beyond the ponderomotive force", W. Fox talk was titled "Astrophysical Weibel instability in counter-streaming laser-produced plasmas", the H. Qin talk was titled "Analytical methods for describing charged particle dynamics in general focusing lattices using generalized "X-point-position-dependent intrinsic rotation in the edge of TCV".

The SciDAC Center for Extended MHD modeling held a meeting in New Orleans, in conjunction with the APS-DPP meeting. Presentations were made on M3D-C1 and NIMROD code development involving effects of resistive walls, automatic island detection, and continuum kinetics. Application presentations included the modeling of tokamak edge modes, disruptions, and sawteeth. There were also presentations on the new Resistive DCON capability, and a discussion of how to best combine fluid and transport modeling of tokamak plasmas. Copies of the presentations can be found at: <http://w3.pppl.gov/ceem/APS2014/index.html>

A project meeting was held at the APS-DPP meeting for the SciDAC Center of Simulation of Energetic Particles in burning plasmas (CSEP). G. Fu organized the meeting that was attended by scientists from University of Colorado, IFS and PPPL. The agenda of the meeting included review of progress made in the past 12 months and discussion of future plans. The work on stability of energetic particle-driven TAE in ITER was one of highlights from past year. This work used the gyrokinetic simulations with GEM code to show that high-n TAE driven by alpha particles and beam ions are strongly unstable in the ITER steady-state operation.

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

Two Plasma Science & Technology Seminars were given this week. The first one was presented by Shantanu Karkari from Institute for Plasma Research, India, titled "An Overview of Ongoing Plasma Physics Experiments related to APPEL Device." Abstract reads: "The Applied Plasma-Physics Experiments in Linear Device (APPEL), currently under development at the Institute for Plasma Research, is primarily motivated towards pursuing plasma physics experiments associated with strongly magnetized sheaths and its consequence on anomalous cross-field transport in bounded magnetized plasmas. Besides the device shall be used for studying the effect of hydrogen permeation in tungsten, as it is currently relevant to ITER-TBM test-blanket module. The physical examination of such phenomenon requires a detail understanding about the equilibrium characteristics of the plasma column. This is likely to depend on the properties of magnetized plasma sustained by the external source in conjunction with the material electrodes that are in physical contact with the plasma. In this context the discharge mechanism, inclusive of the source geometry plays a crucial role in determining the equilibrium properties in magnetized plasma system. The talk briefly overviews the development of the APPEL device in conjunction discusses the equilibrium characteristics of the magnetized plasma column sustained by dc magnetron discharge. In particular the radial plasma characteristics obtained with a set of

planar Langmuir and emissive probes reveal the existence of electron temperature gradient in association with central density peaking observed in argon discharge. Contrastingly with electro-negative oxygen plasma, a hollow density profile is found. The observed features are attributed due to the presence of conducting end plate acting as the anode. While in electro-negative plasma, a technique to quantify negative ions based on electro-static probe points towards the existence of ion-ion plasma in the central plasma column. Finally a method for determining electron density based on quarter-wave resonator probe and its potential application for quantifying sheath models shall be briefly discussed.

The second seminar was presented by Mikhail Shneider of Princeton University, titled “Dynamic Contraction of the Positive Column of a Self-Sustained Glow Discharge in Molecular Gas Flow”. The abstract reads: “Contraction of the gas discharge, when current contracts from a significant volume of weakly ionized plasma into a thin arc channel, was attracted attention of scientists for more than a century. Studies of the contraction (also called constriction) mechanisms, besides carrying interesting science, are of practical importance, especially when contraction should be prevented. A set of time-dependent two-dimensional equations for the non-equilibrium weakly-ionized nitrogen / air plasma is formulated. The process is described by a set of time-dependent continuity equations for the electrons, positive and negative ions; gas and vibrational temperature; by taking into account the convective heat and plasma losses by the transverse flux. Transition from the uniform to contracted state was analyzed. It was shown that such transition experiences a hysteresis, and that the critical current of the transition increases when the pressure (gas density) drops. Possible coexistence of the contracted and uniform state of the plasma in the discharge where the current flows along the density gradient of the background gas was discussed. In this talk the problems related to the dynamic contraction of the current channel inside a quasineutral positive column of a self-sustained glow discharge in molecular gas in a rectangular duct with convection cooling will be discussed. Study presented in this talk was stimulated by the fact that there are large number of experiments on the dynamic contraction of a glow discharge in nitrogen and air flows and a many of possible applications. Similar processes play a role in the powerful gas-discharge lasers. In addition, the problem of dynamic contraction in the large volume of non-equilibrium weakly ionized plasma is closely related to the problem of streamer to leader transitions in lightning and blue jets.

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

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

Construction: The centerstack is in NSTX and its final elevation is being adjusted. The upper ceramic break and PF1C coil have been installed. The Vacuum Prep Laboratory (VPL) is preparing the final items for the vacuum boundary as well as blank-offs for ports where hardware has yet not been provided. Re-machining of the TF lead extensions has been started. Preparations are underway for performing the neutron calibration on November 7 and the MPTS in-vessel work, calibrations and alignments on November 10-12.

CS Upgrade: Cleanup of the TF Lead extensions commenced at D-Site machine shop. Insulation of the PF busbars continued at C-site. A meeting was held to review the requirements and potential solutions for the OH cooling wave. An estimate is being prepared for a cooling system design change to spread the heat wave out over the length of the coil.

NBI Upgrade: Services work continues on turbo vacuum lines. HVE leakcheck continues and HVEs have been filled. The surge room, and mod/ reg work continued, in anticipation of Accel reactivation. The BL2 N4A M/R was activated and pulsed on low voltage for testing. All HVST vac ion pumps have been turned on and found to be acceptable. Controls work continues with installation of cable, trays, and terminations. Progress continues on PLC software pages. Cryogenics maintenance and repairs in preparation for operations continues. The shield wall drawing was approved. Development of NB procedures continues.

Digital Coil Protection System: Final editing of the real world PTP continued and dry run tests continue. DCPS software tweaks, PTP testing, and bug investigations continued as background activities. The SW PTP has been approved. Development of a DCPS System Design Description and Reliability Assessment continues per requirements. A junction area interface concept for DCPS FCC signals has been developed for a meeting the week of November 2.

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

PPPL submitted a proposal to NASA titled "A Multiscale Investigation of Electron Acceleration by Alfvén Waves during Solar Flares." The Principal Investigator is P. Damiano. The total PPPL budget is \$353,400 for the three-year period of performance.

### **OFFICE OF COMMUNICATIONS (K. MACPHERSON):**

Members of the Communications team represented PPPL and attended the NJ Chamber of Commerce 350th anniversary of the founding of New Jersey gala event October 27. Of the top 20 New Jersey Innovators honored, special recognition was accorded to the top five, which included Lyman Spitzer and the founding of PPPL.

### **BEST PRACTICES & EXTERNAL AFFAIRS (J. DELOOPER):**

PPPL participated in the Science Teacher's Day on October 28 where 67 middle and high school teachers attended; John DeLooper led the Plasma 101 workshop for middle school teachers. PPPL was also represented by the Science Education department and many PPPL staff volunteers at the Plasma Science Expo on October 30-31. About 1600 students attended the outreach event.

### **OFFICE OF ACADEMIC AFFAIRS (N. FISCH):**

I. Dodin, a Lecturer in the Program in Plasma Physics at Princeton University and a member of the PPPL Theory Division, was awarded the American Physical Society 2014 Thomas H. Stix Award for Outstanding Early Career Contributions to Plasma Physics Research. The award was presented at the Annual Meeting of the APS Division of Plasma Physics October 27-31 in New Orleans, Louisiana. Dodin is the first recipient of the award, which was named in honor of Professor Thomas H. Stix. The award was established to recognize an individual researcher who

has made outstanding contributions (theoretical, experimental, computational, or technical) in plasma physics early in their career. The award citation reads: "For the prediction of interesting new wave effects in non-stationary plasmas and for the elegant variational formulation of wave-particle and wave-wave interactions that generalizes the ponderomotive force theory."

#### **AWARDS:**

Dodin, I., 2014 Thomas H. Stix Award for Outstanding Early Career Contributions to Plasma Physics Research, APS Division of Plasma Physics.

#### **INVITED TALKS:**

Ahn, J-W. (ORNL), "Broadening Of The Divertor Heat Flux Footprint With Increasing Number Of ELM Filaments In NSTX," APS-DPP Meeting, New Orleans, Louisiana

Belova, E., "Energy Channeling and Coupling of Neutral-beam-driven Compressional Alfvén Eigenmodes to Kinetic Alfvén Waves in NSTX," APS-DPP Meeting, New Orleans, Louisiana

Capece, A., "The Effects of Temperature and Oxidation on Deuterium Retention in Solid and Liquid Lithium Films on Molybdenum Plasma Facing Components," APS-DPP Meeting, New Orleans, Louisiana

Churchill, M.R., "Poloidal Asymmetries in Edge Transport Barrier," APS-DPP Meeting, New Orleans, Louisiana

Diallo, A., "Edge Instabilities Limiting the Pedestal Evolution," APS-DPP Meeting, New Orleans, Louisiana

Dodin, I., "The Ponderomotive Effect Beyond The Ponderomotive Force," APS-DPP Meeting, New Orleans, Louisiana

Fox, W., "Astrophysical Weibel Instability In Counter-Streaming Laser-Produced Plasmas," APS-DPP Meeting, New Orleans, Louisiana

Grierson, B., "Impurity Particle Transport in High Confinement Regimes Without ELMs on DIII-D," APS-DPP Meeting, New Orleans, Louisiana

Lore, J. (ORNL), "Simulation of 3D Effects On Partially Detached Divertor Conditions in NSTX and Alcator C-Mod," APS-DPP Meeting, New Orleans, Louisiana

Lyons, B.C., "Coupled Neoclassical Magnetohydrodynamic Simulations of Axisymmetric Plasmas," APS-DPP Meeting, New Orleans, Louisiana

Ono, M., "Recent Progress On Spherical Torus Research And Implications For Fusion Energy Development Path," APS-DPP Meeting, New Orleans, Louisiana

Qin, H., "Analytical methods for describing charged particle dynamics in general focusing lattices using generalized Courant-Snyder Theory," APS-DPP Meeting, New Orleans, Louisiana

Raites, Y., "Effects of Anomalous Electron Cross-Field Transport in a Low Temperature Magnetized Plasmas," APS-DPP Meeting, New Orleans, Louisiana

Sabbagh, S.A. (Columbia U.), "Unification of Kinetic Resistive Wall Mode Stabilization Physics in Tokamaks," APS-DPP Meeting, New Orleans, Louisiana

Schmitt, J., "High Performance Discharges in the Lithium Tokamak Experiment with Liquid Lithium Walls," APS-DPP Meeting, New Orleans, Louisiana

Stoltzfus-Dueck, "X-Point Position Dependent Intrinsic Rotation in the Edge of TCV," APS-DPP Meeting, New Orleans, Louisiana

Wang, Z.R., "Drift Kinetic Effects on 3D Plasma Response in High-beta Tokamak Resonant Field Amplification Experiments," APS-DPP Meeting, New Orleans, Louisiana

Yamada, M., "Experimental Study of Energy Conversion in Magnetic Reconnection Layer," APS-DPP Meeting, New Orleans, Louisiana

This report is also available on the following web site:

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