PRINCETON PLASMA PHYSICS LABORATORY

WEEKLY highlights

PPPL

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending May 8, 2015, are as follows:

FEATURED HIGHLIGHTS:

Physicist Luis Delgado-Aparicio has won an Early Career Research award sponsored by the DOE's Office of Science. The five-year grant will fund Delgado-Aparicio's research aimed at eliminating impurities in fusion plasmas.

On May 4-7, PPPL hosted the FES-sponsored community-led workshop on plasma-materials interactions (PMI). Approximately 80 registered attendees from all over the country, and a few from ITER, presented talks, discussed white papers, and identified scientific challenges in the areas of PMI science. The groups also discussed proposed actions to address those challenges, in four categories: a) upgrades to existing facilities, b) theory & modeling, c) international collaborations, and d) new starts. The discussions were vibrant and dynamic, and will form the basis of the workshop report due to FES at the end of June. The workshop was chaired by R. Maingi (PPPL) and S. Zinkle (UT-K).

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

The ship carrying the last two of four HV transformers entered the Mediterranean Sea this week, with delivery at Fos du Mer, France scheduled for early during the week of May 11.

A team of six engineers and project managers from the EUDA and the company IDOM visited PPPL this week to discuss ITER diagnostic port plug engineering and integration. IDOM is the primary contractor for all EU port plug engineering and integration. The PPPL engineering team presented case studies and design guidance based on experience from the last three to four years.

The port plug analysis team completed reports for SOFE meeting on mapping out EM environment (normal operation and plasma events) and thermal environment (normal operation and baking); as well as identifying the worst case EM scenarios for in-port diagnostic systems and components in ISS/PC region for both UPP and EPP. Results will be used to guide the system load spec development.

An important meeting was held this week on the placement and cooling of the TIP diagnostic corner cube reflectors. The CCRs are embedded in blanket shield modules on the other side of the machine that are being fabricated by the China DA. The cooling of the CCRs is critical for the optical performance and the USDA is trying to be more involved in the design and analysis of these blankets.

A prototype TIP CCR, fabricated by Imperial Machine, was accepted for delivery after inspection at PPPL. This prototype will tested at PPPL to validate the capability to fine tune the optical performance of the assembled component.

ITER & TOKAMAKS (R. HAWRYLUK):

R. Hawryluk participated in the ITER Organization Selection Board meeting last week.

DIII-D (R. Nazikian):

Shaun Haskey visited PPPL this week to attend an XGC training course with R. Hager and C.S. Chang. B. Grierson and S. Haskey plan to use XGC to model the main ion/impurity transport and distribution in the DIII-D pedestal and compare to data from the recently installed edge main ion CER system.

A design review for the phase 1 upgrade of the ECE-Imaging and MIR diagnostics was successfully completed this week. The planned upgrade of the ECE-I will provide the required technology for a ten-fold improvement in the signal to noise with absolutely calibrated, fast-sweeping profile measurement capability. The technology has been developed by Professor Anh-Vu Pham's mm-wave research group at University of California - Davis. Fabrication of liquid crystal polymer (LCP) heterodyning receiver circuits is now set to begin ahead of schedule, with prototype V-band circuits to be fabricated and tested over the coming months.

A. Nagy and DIII-D staff performed loss measurements at 500 MHz on the 180-foot long, nine-inch diameter coax transmission line used for the 180-degree ABB antenna. Results showed an attenuation of -0.083 db/100ft, which is just above the manufacturers rating of -0.07db/100 ft. For the Helicon system, the needed length of nine-inch transmission line would produce a loss of -0.276 db total at 500 MHz. This is within the allowable transmission line loss needed for coupling 1 MW of Klystron power to the antenna. This allows the use of the existing transmission line infrastructure for the Helicon system.

ADVANCED PROJECTS (H. NEILSON):

A paper titled "Examination of the Entry to Burn and Burn Control for the ITER 15 MA Baseline and Hybrid Scenarios", by C. E. Kessel, F. Koechl, and S. H. Kim, has been accepted for publication in Nuclear Fusion. The paper is the result of simulations in the ITPA Integrated Operating Scenarios group. The paper describes several uncertainties in the entry to burn phase, and models their impacts. These include the rate of rise of the density, the auxiliary power and its margin to the L-H power threshold, the H-mode regimes accessed, the onset of high-Z impurities, different controlled variables such as stored energy, SOL power or fusion power, and the inclusion of particle control. Slow and fast perturbations were introduced in the simulations. These early studies indicate that the scalar proportional-derivative feedback control is sufficient for the inductive operating modes of ITER. However, future work will begin to include measurement and actuator limitations in more detail. An important observation of the studies is that ITER will require a way of assessing the plasma state at any given time in order to take

appropriate control actions, to avoid radiative collapses or unreachable outcomes for example. This finding is expected to apply to future steady-state fusion devices, such as a fusion nuclear science facility (FNSF), and will drive requirements for their diagnostic and control systems.

The Laboratory and the Chinese Academy of Sciences' Institute for Plasma Physics (ASIPP) have signed a Strategic Partnership Project (SPP) agreement for joint research on next-step fusion devices. Under the agreement, PPPL will perform engineering analyses contributing to the evaluation of design options for China's Fusion Engineering Test Reactor (CFETR). Initial studies will focus on high-field magnet concepts and hybrid breeding blanket concepts. A high magnetic field design can be advantageous as a means to either increase fusion power density while maintaining safe margins against plasma physics limits. A hybrid blanket design, incorporating two blanket types, would enable CFTER to simultaneously test two-blanket designs, differing for example in their coolant or breeding materials. Since concepts such as these are relevant to a future U.S. fusion nuclear science facility (FNSF), the collaboration will generate knowledge that can inform future U.S. decisions. Under the agreement, PPPL's work will be funded by ASIPP.

The Wendelstein 7- X-ray imaging crystal spectrometer diagnostic project issued its last procurement with the placement of an order with Metal Flex Bellows for the stainless steel bellows assembly. With this significant milestone, the project is now focusing on the manufacturing process, which is proceeding smoothly. Many parts have been completed and all parts to be fabricated by external vendors are currently scheduled to arrive by early June. A meeting will be held with the W7-X assembly team in May to arrange a schedule to install the bulk of the major diagnostic components with a tentative target date of mid-June.

THEORY (A. BHATTACHARJEE):

H. Mynick gave the Theory Department Research and Review Seminar entitled "Turbulent optimization of stellarators & tokamaks" on May 8. The abstract reads: "We have developed & applied a method for "turbulent optimization" of stellarators & tokamaks, using shaping to obtain toroidal configurations with appreciably reduced levels of turbulent transport. This is analogous to what was done starting in the 1980s for neoclassical transport in stellarators, making those devices far more attractive as a fusion reactor concept. The method makes use of a gyrokinetic code (GENE) and the stellarator optimization code STELLOPT. In this talk I'll describe the method & give an overview of the progress we have made so far using it."

R. Churchill gave a plenary talk on April 28 at the Transport Task Force (TTF) Workshop, in Salem, Massachusetts. The talk was titled "Pedestal and edge turbulence characteristics from XGC1 simulations". Understanding the multi-scale physics in the edge region (pedestal + scrape-off layer) is required in order to reliably predict performance in future fusion devices. The present production version total-f, gyrokinetic code XGC1 includes many of the physics important in setting the transport in the edge region, including neoclassical and electrostatic turbulent transport effects, kinetic electrons, full magnetic geometry including X-point, and neutrals with atomic cross-sections. Here we will explore turbulent characteristics in the edge region from XGC1 simulations in the DIII-D tokamak geometry. For an H-mode type plasma with steep pedestal, it is found that the electron density fluctuations increase towards the separatrix, and stay high well into the SOL, reaching a maximum value of dne / ne ~0.18. Blobs

are observed in the SOL on the order of dne / ne =1.5 - 3, with many being born in the pedestal region and propagating radially outward with velocities around 2 km/s. Strong poloidal motion of the blobs is also present, near 20 km/s, consistent with ExB rotation. The poloidal blob birth location is localized to the LFS, but dominantly above the midplane. Skewness profiles of the electron density fluctuations show a negative skewness in the closed field line pedestal regions, consistent with the presence of holes, followed by a transition to strong positive skewness across the separatrix and into the SOL. Coherent modes are present in the pedestal and SOL regions, changing sign in lab frame velocity with the self-consistently calculated ExB flow. These simulations indicate that turbulence, including the blob-generation mechanisms, can remain important in the steep H-mode pedestal and SOL. Qualitative comparisons will be made to experimental observations.

On May 6, Albert Mollén (Chalmers) presented a theory seminar on impurities in a non-axisymmetric plasma: transport and effect on bootstrap current: In stellarator plasmas the neoclassical ambipolar radial electric field is often unfavorable for avoiding strong impurity peaking. In this work he used a new continuum drift-kinetic solver, the SFINCS code (the Stellarator Fokker-Planck Iterative Neoclassical Conservative Solver) [M. Landreman et al., Phys. Plasmas 21, 042503 (2014)], which employs the full linearized Fokker-Planck operator, to calculate neoclassical impurity transport coefficients for a Wendelstein 7-X magnetic configuration. He compared SFINCS calculations with theoretical asymptotes in the high collisionality limit. He showed that a momentum conserving collision operator is critical to correctly determine the impurity transport coefficients at high collisionality. In the low collisionality regime pitch-angle scattering is sufficient to accurately describe impurity transport through self-interaction, but lacks the ability to describe inter-species interaction. He also used SFINCS to analyze how the impurity content affects the bootstrap current, and showed that a change in plasma effective charge of order unity can affect the bootstrap current enough to cause a deviation in the divertor strike point locations.

The invited paper of R. Churchill was given at the APS DPP Meeting and published in Physics of Plasmas, entitled "Poloidal asymmetries in edge transport barriers" http://dx.doi.org/10.1063/1.4918353. The abstract reads: “Measurements of impurities in Alcator C-Mod indicate that in the pedestal region, significant poloidal asymmetries can exist in the impurity density, ion temperature, and main ion density. In light of the observation that ion temperature and electrostatic potential are not constant on a fluxsurface [Theiler et al., Nucl. Fusion 54, 083017 (2014)], a technique based on total pressure conservation to align profiles measured at separate poloidal locations is presented and applied. Gyrokinetic neoclassical simulations with XGCa support the observed large poloidal variations in ion temperature and density, and that the total pressure is approximately constant on a fluxsurface. With the updated alignment technique, the observed in-out asymmetry in impurity density is reduced from previous publishing [Churchill et al., Nucl. Fusion 53, 122002 (2013)], but remains substantial (nz,H/nz,L~6). Candidate asymmetry drivers are explored, showing that neither non-uniform impurity sources nor localized fluctuation-driven transport are able to explain satisfactorily the impurity density asymmetry. Since impurity density asymmetries are only present in plasmas with strong electron density gradients, and radial transport timescales become comparable to parallel transport timescales in the pedestal region, it is suggested that global transport effects relating to the strong electron density gradients in the pedestal are the main driver for the pedestal in-out impurity density asymmetry.

PLASMA SCIENCE AND TECHNOLOGY (P. EFTHIMION):

This week's Plasma Science &Technology Department seminar was presented by André Anders from Lawrence Berkeley National Laboratory. The title of his talk was "Metal plasmas have been studied for decades (and actually even longer) for applications in coatings, high power switching, or simply because they appeared as a nuisance in processes (like "arcing" in magnetron sputtering). In this seminar, he revisited some early observations and touched upon various topics related to arcs and magnetron discharges. He stressed the importance of electric fields near surfaces, surface conditions, and report on modes of arc discharges in the context of electron emission mechanisms. Turning to newer observations in magnetron plasmas, he showed ionization instabilities that exhibit signs of self-organization and chaos."

ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):

NSTX Upgrade (R. Strykowsky, E. Perry, L. Dudek, T. Stevenson):

CS: Cleanup from the OH Circuit fault continued this week. An internal review of the OH Circuit fault was held on May 8.

NBI: Efforts continue to operate NSTU NBI BL2 sources ABC to reach KPP levels and complete CD4. Progress continues on BL1 with turbo molecular pump replacement. Armor thermocouple troubleshooting and software changes were completed.

DCPS: PCS DCPS continues to support ongoing rectifier dummy load testing. OP-DCPS-779 was revised to improve the daily checklist attachment.

BUSINESS OPERATIONS (K. FISCHER):

The Business Systems Upgrade Project (BSUP) contract was executed on May 6. The kick-off meeting was held at PPPL on May 7.

DIRECTOR'S OFFICE (C. AUSTIN):

On May 1, S. Prager visited Tri-Alpha-Energy, Incorporated in in Foothill Ranch, California for a discussion about field reversed fusion configurations.

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