PRINCETON PLASMA PHYSICS LABORATORY
WEEKLY highlights

PPPL
U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending September 6, 2013, are as follows:

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

PPPL sign off was completed for a Statement of Work and Source Selection Plan for design support for the ITER Upper Visible/IR Cameras. PPPL sign off was also completed for the Statement of Work for design support for the ITER Electron Cyclotron Emission diagnostic. PPPL Procurement is now assembling these Request for Proposal Packages for DOE Review.

The ITER diagnostic shield modules (DSMs) are envisioned by the ITER Organization as monolithic forgings with cavities to accommodate diagnostic components. Manufacturing these large structures with complicated labyrinths and cooling channels will be expensive. PPPL engineers have been investigating an alternate, potentially cheaper and more flexible approach, using welded plates with gun-drilled holes as a frame which holds non-structural shielding blocks. Preliminary analysis of this approach indicates that such a structure would have sufficient stiffness to react the loads produced by the diagnostic first wall panels which bolt to the front of the DSMs and which carry most of the eddy currents produced in a disruption. This concept was presented to the IO diagnostic engineers this week, who supported this direction of investigation.

PPPL presented an alternate design for another feature of the DSMs related to blocking of radiation streaming through the 5 mm gaps between DSMs. The IO generic design includes radially-running ribs which interleave along adjacent DSM sides to reduce the solid angle for such streaming while maintaining the 5 mm clearance and allowing for independent DSM removal. Such features would be expensive to machine and would take up valuable diagnostic space without adding much structural rigidity. An alternate approach presented to IO diagnostic management this week utilizes rods which are inserted vertically after the DSMs are installed and which fill vertical slots in the DSMs running perpendicular to the streaming path. Preliminary neutronics analysis indicates that 2 or 3 of these rods are very effective at reducing radiation streaming. The IO encouraged further PPPL work in this area and offered to use its resources to investigate this as well.

NSTX (M. ONO):

Professor Tom Jarboe and Dr. Brian Victor of University of Washington visited PPPL to discuss the imposed dynamo current drive research at HIT-SI with the NSTX-U and PPPL researchers. Jarboe gave an Experimental Seminar entitled “Progress with the HIT-SI experiment and Imposed Dynamo Current Drive”. In HIT-SI (Ro = 0.34 m, a = 0.23 m) two inductive helicity injectors, oscillating 90º out of phase, continually drive edge currents and impose perturbations.

[Victor B. S. et al., Phys. Rev. Lett. 107, 165005 (2011).] Results including toroidal currents of over 90 kA, current gains (I_tor/I_inj) of 3.9, the highest ever achieved in a spheromak, and frequency scans from 14.5 kHz to 68.5 kHz are presented. Experimental data and two-fluid MHD simulations show the n=1 injectors initially building up an n=1 structure that reconnects to form the n=0 spheromak. The spheromak current then increases quiescently with the level of n=1 decreasing to only that imposed. By driving the edge current high and imposing high frequency fluctuations, a kink stable equilibrium can be very efficiently sustained with minimal interchange losses. Results from a reactor study are presented that show a spheromak reactor based on this current drive method would be economically competitive, even with natural gas. The presentation material is downloadable from the following URL:
http://nstx.pppl.gov/DragNDrop/NSTX_Meetings/Monday_Physics_Meetings/2013/2013_08_29/

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

B. Grierson recently collaborated with Martin O'Mullane from ADAS to obtain charge-exchange emission rate coefficients for fully ionized fluorine F-IX (10-9) from ground state and n=2 excited state beam neutrals. These new rate coefficients are being used with a new impurity density analysis tool written by Grierson for analysis of recent fluorine puff experiments. The absolute fluorine density profile can now be calculated, enabling quantitative transport analysis of this light impurity. This work is part of the PPPL contribution to the JRT on understanding particle transport in regimes with mitigated ELMs.

The ECH Gyrotron 8 water manifold assembly is 90% completed, including weldments, pressure testing and assembly at Astro Machine Inc (weldment fabricator). The unit is expected to arrive at GA on September 11 and once here additional items will be added such as local pressure gauges/thermometers/bleed valves/gate valves and a conformance inspection. The assembly is expected to be installed in the ECH vault by October, when the water supply lines are set to be connected.

ADVANCED PROJECTS (H. NEILSON):

The Laboratory submitted an interim report to S. Korea's National Fusion Research Institute (NFRI) summarizing work performed to date in its research and development collaboration on K-DEMO. The report details the results of PPPL work in each of four areas, namely system code analysis, device modeling, structural analysis, and superconductor analysis. A key accomplishment of the NFRI-PPPL team during the reporting period was the selection of a K-DEMO design point. The chosen design is based on a superconducting-magnet tokamak with major radius 6.8 m and toroidal magnetic field of 7.4 T at the plasma. The team has begun to develop the design at a pre-conceptual level based on mission requirements and magnet concepts provided by NFRI, a maintainable tokamak machine configuration provided by PPPL, and the chosen design point. In addition, analysis tasks to validate the chosen design point are under way. The report noted that the team presented its work in five papers (including three with U.S. first authors) at international conferences during the reporting period. An extension of the

collaboration agreement to February 2014, when NFRI must submit its Conceptual Study Report, is currently being negotiated.

In the monthly stellarator team meeting, team members reported the status of accomplishments against their FY-2013 work plans and described their plans for FY-2014. The meeting highlighted several accomplishments in stellarator physics during the fiscal year. Transport analysis using data from the U.S. x-ray imaging crystal spectrometer is elucidating the transport properties of an important class of Large Helical Device (LHD) discharges, and major advances in methods and applications for 3D equilibrium reconstruction for stellarators and tokamaks have been made. These accomplishments will be reported this month at the International Stellarator Heliotron Workshop in Padova. In addition, major improvements to stellarator coil optimization tools provide new opportunities for stellarator design improvements, and a multi-national collaboration on stellarator gyrokinetic code applications has advanced the development of tools and understanding in preparation for Wendelstein 7-X.

In PPPL's collaboration with Max Planck Institute for Plasma Physics, interconnecting cable for the Wendelstein 7-X trim coil power system was delivered to the project site in Greifswald, Germany. The five power supply units have been shipped by our supplier, Applied Power Systems of Hicksville, New York, and are currently en route to Greifswald.

THEORY (A. BHATTACHARJEE):

The theory seminar this week was presented by Dr. I. Kaganovich from PPPL on "Collective Beam-Plasma Interactions for Fusion and Plasma Processing Applications". Here is the abstract of his talk: The beam-plasma interaction is one of the most important phenomena in plasma physics and its applications. A recent resurgence of interest in beam-plasma interactions is due to the ability of advanced particle-in-cell codes to simulate many aspects of the complex processes observed in experiments on beam-plasma interactions relevant to plasma processing of semiconductors. I will give examples of beam self-organization phenomena that occur because of nonlinear saturation of instabilities and their subsequent evolution. The first example is an electron beam undergoing the Weibel filamentation instability. We demonstrate that the beam splits into many filaments and then the filaments undergo collective interactions and nonlinear mergers. The final state of the process is a single pinched beam surrounded by a wide halo. The second example is an ion beam propagating in background plasma. An ion beam can effectively excite plasma waves and whistler waves when propagating in plasma. The two-stream instability between the beam ions and plasma electrons cause further growth of plasma waves, which in turn leads to a significant enhancement in the plasma return current and a defocusing of the beam. The final example is relevant to plasma processing applications. The two-stream instability of an intense electron beam in finite-length plasma with nonuniform density is investigated numerically. A new regime of the instability is observed where intense plasma oscillations occur near the plasma edges. Here, bulk electrons can be accelerated to substantial energies in the direction opposite to the beam propagation direction. The new regime appears stochastically and only for strong beam currents.

The Edge Particle Code (EPC) was created by PPPL long term visitor Xujing Li and Dr. L.E. Zakharov using recently developed Edge Equilibrium Code (EEC) and Equilibrium and Stability Code (ESC) as a first step for simulating power and particle losses from the magnetically

perturbed plasma edge. EPC utilizes the high performance of GPU processors and was validated by comparison of collisional particle diffusion with neoclassical theory.

ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):

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

Construction: Welding of the vacuum vessel stiffeners in bays J and K has been completed. Welding of the splice plates for the upper outer TF structure is now 70% complete. Welding of the tFIDA tube to the vessel is in progress. The assembly of the MPTS optics box continues.

CS Upgrade: The Bus Bars design and analysis continued this week. Tech shop started fabrication on the buss bars and procurement of additional copper materials is in progress. The full TF Bundle is ready for installation into the mold. The final pieces required for the lift, end spacers, are being reworked to as-built coil dimensions in the Tech Shop. The parts are requiring multiple iterations of machining to ensure a proper fit. Machinists are scheduled through the weekend to complete the machining on the spacers and mold end plates. The lift into the mold is now scheduled for Monday of next week. The OH winding station is being worked on in the C-site MG area. The final punch list items are being addressed before the station is transported to the winding area next week. The brazing and cutting station have been mounted. The OH winder coil end mounts have been moved into the CS building in preparation for the Installation of the OH Winding station.

OFFICE OF COMMUNICATIONS: (K. MACPHERSON):

J. Greenwald's news release about PPPL's role in the development of a novel egg pasteurization process was picked up by a wide range of media outlets, including a French news magazine, and the Trenton Times:
http://www.nj.com/mercer/index.ssf/2013/09/fresh_eggs_princeton_researchers_use_radio_frequencies_to_pasteurize_sensitive_yolks_quickly.html .
In addition, the latest issue of DOE Pulse featured Greenwald's piece about PPPL's work on a nuclear warhead verification protocol as the lead item:
http://web.ornl.gov/info/news/pulse/.

DIRECTOR'S OFFICE (C. AUSTIN):

Dr. Bécoulet presented a seminar to research staff entitled "Science and technology research & development in support to ITER: The WEST project".

INVITED TALKS:

S. Ethier gave an invited talk at the NumKin 2013 workshop held at the Max-Planck Institute for Plasma Physics (IPP) in Garching, Germany. The purpose of this workshop was to bring together

a small number of specialists in the development of numerical methods for collisionless and collisional kinetic equations, and discuss the current evolutions in the field.Dr. Ethier presented some of the algorithms used in PPPL's Gyrokinetic Tokamak Simulation (GTS) code. (Computational Plasma Physics Group)

PUBLICATIONS:

F. Ebrahimi's manuscript on "Magnetic reconnection process in transient coaxial helicity injection" (F. Ebrahimi, B. Hooper, C. Sovinec, and R. Raman) was accepted for publication as a Letter in Physics of Plasmas. It is tentatively scheduled for publication in the October issue. She is also a co-author on a paper by B. Hooper, C. Sovinec, R. Raman, F. Ebrahimi and J. Menard on "Resistive MHD simulation of helicity-injected startup plasmas in NSTX", which is also accepted for publication in PoP and scheduled for publication in the November issue. (Theory)

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