PRINCETON PLASMA PHYSICS LABORATORY

WEEKLY highlights

PPPL

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending October 16, 2015 are as follows:

U.S. ITER FABRICATION (C. NEUMEYER):

Steady State Electric Network (SSEN):

In response to DOE comments, the department prepared and submitted another revision of "Red Book" recommending award of contract for Reactive Power Compensators procurement.

The department obtained approval of an ITER Credit request for in-kind deliveries of HV Substation Transformers Unit One and Two, HV Current Transformers, HV Potential Transformers, HV Control and Protection, HV Surge Arresters, HV Circuit Breakers, HV Switches, HV Substation Hardware, 22kV Switchgear, and Earthing Resistors.

Diagnostics:

Motional Stark Effect (MSE) Diagnostic: The ITER MSE diagnostic system contract was awarded to Nova Photonics of Princeton, New Jersey. There are two MSE systems: a Core Viewing MSE system for F4E Equatorial Port One and an Edge Viewing MSE system for USDA Equatorial Port Three. Nova Photonics will manage the complete optical and physics system design and will also engineer and fabricate MSE equipment in the interspace, port cell, and diagnostic hall. PPPL will engineer and fabricate the MSE in-vacuum components under the guidance of Nova Photonics. A contract kick-off meeting is scheduled for October 23.

Diagnostic Shield Module (DSM) Design and Analysis: Julio Guirao, the chief diagnostic port engineer at the IO, visited PPPL for a week of technical meetings. There were a number of small group discussions focused on: i) the latest design modification of generic port plug structures (EPP and UPP); ii) the new DSM attachment design and DSM-PPS interface model update in ENOVIA; iii) the dynamic impact of EM and seismic inertia loads on PP assembly-design guidance; iv) the IO generic models and US E9/U14 DSM design and analysis update; and v) the EM workshop and SDC-IC/RCC-MR discussions. Guirao presented the new rigid DSM-PPS attachment system and the CAD models of generic port plugs updated in ENOVIA for E9 DSM design. We also worked together on the EPP generic models IO developed and used to perform point spectrum response analysis for any points inside the DSM for evaluating inertia load impact to in-port diagnostics. The results indicate that 80-100 Hz natural frequency range shall be avoided for any piping or diagnostic component attached to the EPP closure plate to avoid a significant (~28g) dynamic amplification during EM inertial loads. The case for UPP is slightly better with a lower frequency range. Based on these meetings the PPPL analysis team is recommending changing the equatorial port DSMs to a Horizontal Split Forging design versus

the current vertically split forging design.

Toroidal Interferometer and Polarimeter (TIP): The ITER TIP real-time alignment full-scale prototype has been commissioned at General Atomics and features two active feedback loops that keep the beams centered on the window and the detector. The range of relative motions between the various components that can be compensated by this system is now under investigation. Apertures in the system will limit this range. PPPL is gathering information on the apertures that exist in the port plug E9 and house TIP relay mirrors.

Diagnostic First Wall: The Task Agreement for the Port Specific Diagnostic First Wall Final Design was awarded to PPPL.

NSTX (M. ONO):

On October 13 – 14, J. Menard (PPPL) visited Hefei, China to serve as co-chair (H. Zohm from IPP Garching is chair) of the first China Fusion Engineering Test Reactor (CFETR) Physics International Advisory Committee (IAC) to review progress made since the start of group activities in late 2014. On October 15, J. Menard observed presentations by the EAST team from the sixth EAST IAC meeting.

F. Poli (PPPL) attended the ITPA-IOS meeting in Hefei, China, from October 12 – 15. She gave a progress report on an activity on integrating a reduced model based on EPED1 in time-dependent simulations. She worked with O. Meneghini (GA) to generate a lookup table for ITER parameters using OMFIT. She also presented TRANSP simulations of a helium plasma for the ITER non-active phase, discussing actuator sharing in the different phases of the discharge.

PPPL NSTX-U researchers, B. LeBlanc, M. Coury, and A. Diallo travelled to Madison, Wisconsin to meet with PSL (Physical Sciences Laboratory) staff on October 8 and Daniel Hartog at the Physics department of University of Wisconsin on October 9. The PSL has been contracted to build the control and power-supply units for the pulse-burst laser system (PBLS). The PSL staff provided a detailed status update on the progress made. The laser head was turned on in flashlamp simmer mode. This first test is crucial to verify the condition of all flashlamps and rods. The six-capacitor banks have been fabricated and one control unit has been built. After the day-long visit at PSL, the PPPL researchers met with Daniel the next day to discuss the integration phase between the power supply and laser head and potential tests necessary to characterize the laser system. At the end of the visit, they toured the MST, HSX, and Pegasus facilities. They also toured the MST laser facility.

The NSTX-U vessel bake continued this past week in parallel with vacuum vessel helium glow discharge cleaning and conditioning operations of the neutral beam # 2 ion sources. Additionally, good progress was made on the dummy load testing of the Switching Power Amplifiers (SPAs) used to power the NSTX-U Resistive Wall Mode coils. Three of the six SPAs have successfully operated into a dummy load, and the other three will be completed by early next week. Pre-operational testing of the Motor Generator's cycloconverter controls was performed, as well as latency measurements of the Plasma Control System (PCS). Physics Operator training was completed this week.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

A paper titled "Local Wave Particle Resonant Interaction Causing Energetic Particle Prompt Loss in DIII-D Plasmas" by Rui-Bin Zhang, G.-Y. Fu, R. White, and Xiaogang Wang has been accepted for publication by Nuclear Fusion. The paper provides a physics basis for intriguing observations on DIII-D of a strong interaction between beam ions and Alfven eigenmodes in a single poloidal orbit. The full orbit analysis shows that a large local resonant interaction can take place in a single poloidal orbit of a beam ion on DIII-D when the phase of the Alfven eigenmode is constant in the frame of the particle orbit.

A paper titled "Evolution of ExB Shear and Coherent Fluctuations Prior to H-L Transitions in DIII-D and Control Strategies for H-L Transitions" by D. Eldon, et al., has been accepted for publication in Physics of Plasmas. The paper characterizes the edge coherent mode that appears as a precursor to the back transition and shows the sensitivity of the transition to plasma rotation.

B. Grierson and S. Haskey have implemented several improvements aimed at simplifying the fitting, analysis, and viewing of data from the main ion CER system on DIII-D using the OMFIT tools. This enables experimental data to be easily compared with simulations from FIDASIM within OMFIT. Additionally, several improvements have been made to the FIDASIM module in OMFIT, which allow the code to be run using the job scheduler on Venus. This leverages the power of the cluster to perform substantially faster runs that previously possible. These developments enable improved throughput and model comparisons for physics studies using the main ion data CER data.

G. Kramer is visiting DIII-D to discuss fast ion modeling in steady state plasmas and to work with collaborators on a paper covering the results of the JRT on the understanding of fast ion transport in high qmin regimes. Gerrit will also initiate a collaboration with Craig Petty to understand the effects of AEs in hybrid plasmas with and without ECCD.

Entry was made into the 330 neutral beamline this week to inspect the PPPL pole shields after running for several months on DIII-D. The pole shields replace the solid copper design used in the past with molybdenum inserts in the high-heat flux region. The inspection found that the tiles look like they did when they were installed, with no heating signs after ~1200 high power shots. This approach appears adequate for DIII-D future needs.

C-Mod (C. Kessel):

C. Kessel participated in the ITPA-IOS topical group meeting in Hefei, China, the week of October 12. He presented some interim results from the helium experiments on C-Mod, which is a new joint experiment in the IOS group, to provide some guidance on the helium discharge phase of ITER. In C-Mod the ELMy H-mode regime is accessed with a special plasma shaping of high lower triangularity (~0.7) and low upper triangularity (~0.2). Several quantities of interest were provided including He concentration, ELM frequency, power threshold to enter the H-mode, power threshold margin in the ELMy H-mode, and confinement quality. These helium discharges are being compared with several deuterium runways that achieved ELMy H-modes to better understand the differences. Overall, the experiments indicate that the helium discharges

would likely exhibit similar behavior to deuterium, and therefore could provide a basis in ITER non-activated phases for the behavior in DD and DT discharges.

Kessel also presented the status of the particle transport benchmark exercise that is on-going in the IOS group. Participants include TSC, TRANSP, TASK (JA), TOPICS (JA), ASTRA (KO), with additional EU efforts expected. There is some disagreement arising from coordinate representations and pinch velocity definitions, which will be corrected in the next steps. This benchmark is intended to provide a simplified scenario of the ITER baseline discharge allowing the comparison of multiple integrated modeling codes. Corrections are made to bring the codes into alignment, while other aspects are recorded where approaches cannot be made similar. With this benchmark in hand, a number of simulations will be pursued to examine all phases of the discharge, and focus on critical particle transport features for modeling. Several of these were presented, including particle source verifications, edge source description, separatrix density constraints, uniqueness of solutions with combinations of D, V, and n(a), and experimental constraints where theoretical guidance is missing.

ADVANCED PROJECTS (H. NEILSON):

H. Neilson participated in the EAST International Advisory Committee, which met from October 15-16 at the Institute of Plasma Physics, Chinese Academy of Sciences (ASIPP), in Hefei, China. The committee was charged with reviewing the research and collaboration plans for the EAST tokamak program. The team presentations stressed the role of EAST in contributing to the physics basis for ITER operation and for the design of the proposed China Fusion Engineering Test Reactor (CFETR) design. It was apparent from presentations and discussion that planning for CFETR is increasingly becoming a focus of the Institute, including the EAST scientific program. The EAST project recently completed a major upgrade of its plasma heating and other systems, so it is now equipped to pursue the development of integrated steady-state scenarios as a central goal. Its collaboration program has matured, now consisting of several substantive partnerships with important goals and deliverables, as well as a good record of producing jointly-authored scientific papers and equipment items.

THEORY (A. BHATTACHARJEE):

An article entitled "Identification of New Turbulence Contributions to Plasma Transport and Confinement in Spherical Tokamak Regime" by W. X. Wang, S. Ethier, Y. Ren, S. Kaye, J. Chen, E. Startsev, Z. Lu, and Z. Q. Li has been published online in Physics of Plasmas 22, 102509 (2015) (http://scitation.aip.org/content/aip/journal/pop/22/10/10.1063/1.4933216). The paper reports the finding of nontraditional turbulence sources in ST experiments through nonlinear global gyrokinetic simulations. The drift wave Kelvin-Helmholtz (KH) instability is identified in strongly rotating NSTX L-mode plasmas. While the strong ExB shear associated with the rotation leads to a reduction in KH/ITG turbulence, the remaining fluctuations can produce a significant ion thermal transport that is comparable to the experimental level in the outer core region (with no “transport shortfall”). The other new, important turbulence source identified in NSTX is the dissipative trapped electron mode (DTEM), which is believed to play little role in conventional tokamak regime. The normal ExB shear stabilization effect on DTEM is found to be surprisingly weak, which makes DTEM a major turbulence source in the ST

regime dominant over collisionless TEM (CTEM). The latter, on the other hand, is subject to strong collisional and ExB shear suppression in NSTX. DTEM is shown to produce significant particle, energy, and toroidal momentum transport, in agreement with experimental levels in NSTX H-modes. Moreover, DTEM-driven transport in NSTX parametric regime is found to increase with electron collision frequency, providing one possible source for the scaling of confinement time observed in NSTX H-modes. Most interestingly, the existence of a turbulence-free regime in the collision-induced CTEM to DTEM transition, corresponding to a minimum plasma transport in advanced ST collisionality regime, is predicted. Also presented in the paper is an accurate delta-f particle simulation scheme used for this study.

An article titled "Maximal Energy Extraction under Discrete Diffusive Exchange" by M. J. Hay, J. Schiff, and N. J. Fisch has been published online in Physics of Plasmas 22, 102108 (2015). http://scitation.aip.org/content/aip/journal/pop/22/10/10.1063/1.4933018. The paper solves a long-standing problem in theoretical plasma physics, namely how much energy can in principle be extracted from a plasma under the diffusion constraint, or, put differently, what is the precise maximum available energy under diffusive rearrangements of phase space density when an arbitrary number of diffusion paths can be constructed. It turns out that the answer to these fundamental questions could be found by making use of mathematical developments in the field of pairwise relaxation transformations. The first author is Michael Hay, a graduate student in the Program in Plasma Physics. The second author is Professor Jeremy Schiff of the Department of Mathematics at Bar-Ilan University.

COMPUTATIONAL PLASMA PHYSICS GROUP (S. JARDIN):

The Isolver free boundary equilibrium code in TRANSP can now include multi-species rotation within the equilibrium solution. A description of the implementation can be found at: http://w3.pppl.gov/~randre/aps2008/RotationSolvers.pdf; it reads that for Mach number of order unity the main ion species becomes more concentrated on the outer major radius side of the flux surfaces, and the impurity density can be even more strongly affected. Documentation is described in transp.hlp under "Isolver Rotation Modified Pressure".

BUSINESS OPERATIONS (K. FISCHER):

Budget Office:

The following three proposals were submitted to NSF: i) “GEM: An Information-Dynamical Approach to Geospace Systems Science”. The proposal is requesting funding for three years in the amount of $386,608. The Principle Investigator is J. Johnson. ii) “GEM Collaborative Research: Comparing Simulations of Electron Acceleration In Kinetic Alfven Waves with Observations from the Van Allen Probes in the Inner Magnetosphere”. The proposal is requesting funding for three years in the amount of $295,120. The Principle Investigator is P. Damiano. iii) “GEM: Collaborative Research: Global Propagation Characteristics of Electromagnetic Ion Cyclotron Wave”. The proposal is requesting funding for three years in the amount of $300,205. The Principle Investigator is E.-H. Kim.

This report is also available on the following web site:

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