Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending September 2, 2016 are as follows:

NSTX-U (M. ONO):

S. Gerhardt (PPPL) will be the recipient of 2016 Excellence in Fusion Engineering Awards. Gerhardt is cited "for your many scientific contributions, including your recent work on plasma disruptions, which will provide major benefit to ITER and other major fusion experiments, and the leadership you provided, and are providing, to the successful completion and operation of the NSTX-U experiment at PPPL."

Visiting graduate student Felipe Bedoya returned to the University of Illinois at Urbana-Champaign (UIUC) last week. He was at PPPL during the last NSTX-U run period, during which he took thesis data with the Materials Analysis and Particle Probe (MAPP). Bedoya used the MAPP to insert graphite and molybdenum alloy (TZM) samples into the NSTX-U vacuum vessel for exposure during boronization and subsequent plasma operations. He was able to characterize the samples after withdrawing them into the MAPP analysis chamber without exposure to air. Bedoya will continue the analysis of the MAPP samples at UIUC, and use the results along with further laboratory studies there for his doctorate from the Department of Nuclear, Plasma, and Radiological Engineering.

All in-situ joint verification testing of the lower TF connections has been completed, and the TF and OH bus inside the lower umbrella has been removed. Daily vacuum vessel Hi-Pots have resumed after finding and correcting a contaminated through-bolt on the upper ceramic break, and machine technicians are in the process of fitting up prototypes for an improved ceramic break bolt bushing design. Radiography of the failed PF1aU coil was performed and analysis of results is in progress as part of the forensics of that failure. Setup of the coil winding facility continues. A preliminary review of plans and schedules to remove the NSTX-U center column and replace both the PF-1A U & L coils was held this week. The neutral beam-lines are being pumped, purged, and vented in preparation for the removal of the calorimeter assemblies for maintenance, and to remove the neutral beam duct for vessel access. The procedure to "safe" the NSTX-U vessel for access with the lockout and tagout of all hazardous energy sources is in progress.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian)

An invited paper of the Conference on High Temperature Plasma Diagnostics (HTPD) that introduces the Synthetic Diagnostics Platform (SDP) for fusion plasmas developed at PPPL has been published online. SDP provides state of the art synthetic reflectometry, Beam Emission Spectroscopy, and Electron Cyclotron Emission (ECE) diagnostics. In particular, a new two dimensional synthetic ECE Imaging module is developed to self-consistently treat refraction and diffraction effects due to the fluctuations. A strong refraction induced non-linearity in the ECE measured signals is identified, and is potentially useful for determining the cross phase between electron density and temperature fluctuations. The Millimeter-wave Imaging Reflectometry and ECEI measurements from a DIII-D EHO case (shot# 157102) are compared to the M3D-C1 simulation results using synthetic diagnostics available on SDP. The comparison has shown qualitative agreement between the experiment and the simulation.

C-Mod (S. Scott)

S. Scott and the C-Mod team carried out 1.5 days of experiments this week on MP826, "Documenting high-performance ELM-free plasmas". This MP was designed to reproduce and then document the reverse-field shots 1160809011 and 014 (0.8 MA, 5.45 Tesla, P_{RF} = 2.5 MW), which experienced a transition into a high-performance, ELM-free H-mode plasma after about 70 ms of RF heating. Those shots attained W_{tot} = 170 kJ, T_{eo} = 7.8 keV, neo = 2.5e20, and Vloop ~ 0.1 volts. Unfortunately the regime proved elusive and we were unable to reproduce it. Like all ELM-free plasmas, once these plasmas transitioned to an ELM-free state they experienced a rapid, ~linear rise in radiated power which inevitably led to radiative collapse in approximately 150 ms. Much of the experimental time centered on efforts to reduce the radiated power and to extend the duration of the high-performance period. Neon puffing simply increased the radiated power. Nitrogen puffing successfully reduced the influx of molybdenum, nevertheless the rate of rise of radiated power following the transition to the ELM-free state was not reduced and the plasma actually suffered a radiative collapse earlier than with no puffing. There were hints in the shots with nitrogen puffing that the edge electron temperature increased with time similar to the behavior observed earlier (shots 1160809011 and 014 had nitrogen puffing) but the performance rolled over in time before the exceptional performance observed previously was achieved. Between-shots boronization did reduce the radiated power and modestly improved the performance of the ELM-free period, yielding central temperatures of 6.5 keV but not quite the performance of 1160809011 and 014. Shots early in the experiment used the cryopump to control density, but this was shown to be unimportant and was abandoned. Several adjustments were made to the plasma strike point in the lower divertor to reduce influx of molybdenum but were unsuccessful.

KSTAR (J-K Park)

J-K Park ran KSTAR experiments remotely from PPPL, with R. Hawryluk and M. Zanstorff participating using new equipment that was recently installed for remote collaboration in room B205. The remote session leading was, in general, highly successful with high-resolution TV display of data and video conferencing. The data transfer through NoMachine was fast enough for timely study and decision between shots, and Webex-based video connection was stable

during the entire half-day session enabling effective communications with KSTAR physics operators and local session leaders. As a result, the experiments "RMP optimization for ELM suppression in KSTAR" were also successfully completed. Various new n=1 field configurations such as +75 phasing were tested and used to achieve ELM suppression up to ~10s. The suppression window for each RMP configuration is qualitatively and also quantitatively consistent with predictions based on linear plasma response modeling and scaling, which therefore can be used to predict n=1 ELM suppression and locking threshold. On the other hand, a gradual degradation was often observed in ELM suppressed discharges after ~10s, suggesting a challenge for ELM suppression using RMP coils for longer timescales.

ADVANCED PROJECTS (H. NEILSON):

C. Kessel attended the ANS Topical Meeting on the Technology of Fusion Energy (TOFE) in Philadelphia, presenting "The Fusion Nuclear Science Facility Overview, Physics Assumptions and Operating Space". The presentation outlined the justification for the facility as an intermediate step toward power plants to address the needed large advances in plasma science toward ultra-long pulse at high performance, and the complexity of the fusion nuclear environment that would be seen for the first time. The facilities program and testing strategies were described, and the pre-FNSF Research & Development in material science, plasma-material interactions, and plasma facing components were presented.

The Laboratory's collaboration with ORNL and Germany's Max Planck Institute for Plasma Physics (IPP) in the fabrication of divertor scraper units for the Wendelstein 7-X (W7-X) stellarator continues to make good progress toward completion by the end of this fiscal year. This week, the graphite tiles for the two units were shipped to a supplier that will perform a final cleaning and bakeout of the tiles in accordance with W7-X cleanliness specifications for in-vessel carbon parts. In addition, all components for the scraper mockup assembly were shipped and are currently en route to IPP. The mockup assembly is prototypical, in terms of external dimensions and weight, of the actual scraper units, and will be used by IPP to develop installation procedures in their vacuum vessel mockup facility. This plan reduces the risks of delays or procedure modifications when the actual units are installed in W7-X.

THEORY (A. BHATTACHARJEE):

A. Bhattacharjee gave an invited talk on "The Shear Current Dynamo: Applications to Astrophysical and Space Plasmas" at the workshop on "Turbulence and Waves in Flows Dominated By Rotation" at the National Center for Atmospheric Research (NCAR), Boulder. The Workshop, which consisted only of invited participants, brought together a group of astrophysicists, geophysicists, solar physicists, and plasma physicists.

A huge challenge for modern computing and experiments is how to handle the massive volume of data that is obtained. M. Churchill and collaborators performed initial network performance tests aimed at enabling high volume data transfer to PPPL from the KSTAR tokamak in Korea. Impressively, sustained data transfer rates of 5 Gb/s were achieved for a single node-to-node connection between a KSTAR ECEi server and a PPPL compute center server. The ADIOS+MDTM framework will be used to seamlessly handle the data transfer, including data

reduction and compression for optimizing data sent. Future plans to utilize multiple nodes and upgrade the Korea to ESNET network bandwidth to 100Gb/s will enable faster transfers. This work was a joint effort with ORNL, FNAL, and NFRI, with funding from the U.S. Department of Energy's FES and ASCR offices.

On August 30, Scott E. Parker (U. Colorado) gave a Theory Seminar on implicit, multi-scale, full kinetics as an alternative to gyro-kinetics. The abstract reads: Recent progress has been made developing full kinetic Lorentz force ion dynamics using implicit multiscale techniques. It is now possible to capture low-frequency physics along with finite Larmor radius (FLR) effects with a fully kinetic multiscale delta-f particle simulation. The utility of such a model is to be able to verify gyrokinetics in situations where the smallness of the ordering parameters is questionable. Additionally, such a model can help identify what higher order terms in gyrokinetics might be important. Orbit averaging and sub-cycling are utilized with an implicit particle time advance based on variational principles. This produces stable and accurate ion trajectories on long time scales. Excellent agreement with the gyrokinetic dispersion relation is obtained including full FLR effects. Ion Bernstein waves and the compressional Alfven wave are easily suppressed with the implicit time advance. We have developed a global toroidal electrostatic adiabatic electron Lorentz ion code. We will report preliminary linear results benchmarking Lorentz ions with gyrokinetics for the Cyclone base case. We will begin by reviewing recent results from the GEM code simulating electromagnetic gyrokinetic turbulence in the edge pedestal where the timestep required is comparable to the ion cyclotron period. The slides of this presentation will soon be available on the Theory Department website: http://theory.pppl.gov/news/seminars.php?scid=1&n=research-seminars

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

The annual Graduate Student Safety Seminar was conducted for nine first year graduate students on September 1. The seminar included introductions by the Deputy Directors for Operations and Research, sessions on hazard awareness, ISM, environmental protection, emergency preparedness and security, and tours of D-Site, LTX and the S-109 machine shop.

DIRECTOR'S OFFICE (C. AUSTIN):

On August 31 and September 1, the DOE Office of Project Assessment conducted an independent project review of the Infrastructure and Operational Improvement Project (IOI) for critical decision 3. The recommendation of the team was to approve CD-3. A formal approval is required by the DOE Energy Systems Acquisition Advisory Board, which is expected in October. Once that approval is completed, PPPL can issue the contract for construction to begin.

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