PRINCETON PLASMA PHYSICS LABORATORY
WEEKLY highlights

PPPL
U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending June 21, 2013, are as follows:

NSTX (M. ONO):

Purdue University graduate students Sean Gonderman and Felipe Bedoya arrived at PPPL last week with the diagnostics chamber for the Materials Analysis and Particle Probe-Upgrade (MAPP-U). Without breaking vacuum, MAPP-U will enable samples to be exposed to NSTX-U plasmas, and perform analyses with X-ray photoelectron spectroscopy, ion-scattering and direct recoil spectroscopy, and thermal desorption spectroscopy immediately afterwards. This summer, the Purdue students will work with PPPL personnel to test the MAPP-U by exposing samples to LTX plasmas.

Dr. Hongbin Ding of the Dalian University of Technology in China visited PPPL on June 21. In the School of Physics and Optical Electronic Technology, Dr. Ding works in the Laboratory of Spectroscopic Diagnosis for Plasma. This is the key laboratory of the Education Ministry of China for the study of material modification by lasers and electron and ion beams. Dr. Ding gave a seminar entitled "Developing Laser Based Technologies for the Diagnosis of Industry Plasma and Fusion Plasma." He also discussed possibilities for joint work with members of the PPPL staff. What might be of interest to NSTX-U is "Cavity Ring Down Spectroscopy" (CRDS). Because it uses a tunable laser, the same apparatus can be used to obtain density data for a variety of species. "Laser-Induced Breakdown Spectroscopy" (LIBS) was also mentioned. While difficult to implement for "real-time" measurements, it may be possible to perform "offline" analysis of samples exposed to NSTX-U plasmas.

Preparations for plasma operations in the NSTX-U configuration with the ongoing fabrication and power testing of the new firing generators for the field coil power conversion (FCPC) system rectifiers. Also this week, a peer review was held to discuss proposed modifications to tiles and backing plates at bays C & I as needed to implement a high conductance Divertor Gas Injection system to replace the somewhat restrictive one formally located at bay E.

ITER & TOKAMAKS (R. WILSON):

Alcator C-Mod (R. Ellis):

D. Mikkelsen worked at MIT this week, assisting with the development of turbulence simulations for C-Mod plasmas in the ohmic LOC-SOC regimes. Ultimately the predicted temperature fluctuations will be compared with measurements made in 2012.

ADVANCED PROJECTS (H. NEILSON):

In the Wendelstein 7-X (W7-X) trim coil collaboration, plans for acceptance testing of the five power supply unit (PSU) were finalized. Staff from PPPL and the Max-Planck-Institute for Plasmaphysik (IPP) will visit Applied Power Systems (APS), the power supply manufacturer, next week to witness testing of the first unit. Testing of the following four PSUs is scheduled in two week intervals thereafter. Delivery of the five PSUs is scheduled for mid-August.

Advanced Projects activities were well represented at the Symposium on Fusion Engineering, held June 10-14 in San Francisco, California. A highlight was a talk by C. Kessel on "Systems Analysis Exploration of the Operating Space for the Korean Demonstration Reactor," reporting work performed in collaboration with South Korea's National Fusion Research Institute. Here studies were used to identify the plasma geometry and toroidal field at the plasma. With these aspects defined, further studies identified the operating space in fusion power versus net electric power. The operating space includes both a lower electric power and lower beta/confinement regime and a higher electric power and higher beta/confinement regime. The impact of various uncertainties was presented, particularly the thermal conversion efficiency, radiated power in the diverter, and allowed peak divertor heat flux.

THEORY (A. BHATTACHARJEE):

Dr. C.S. Chang and the XGC code development group reported progress on the “Spontaneous Edge Rotation Source and its Inward Propagation in H-mode Plasma.” These results were included in the talk Dr. Chang gave at the TTF Conference held in Santa Rosa, California on April 9-12. Understanding the spontaneous co-rotation source mechanism in H-mode tokamak edge and its inward propagation into core plasma is an important subject for ITER --as observed in C-Mod, DIII-D and other tokamaks-- but has remained illusive. The full-f gyrokinetic code XGC1 revealed that there is an inward propagation of co-current directional plasma rotation from the edge of an H-mode plasma in the presence of ITG turbulence. XGC1 also finds that the source of the co-current directional edge momentum is mostly from the Pfirsch-Schluter flow at the low field side. The Pfirsch-Schluter flow is asymmetric in poloidal angle, in the co-current direction at the low field side and in the counter-current direction at the high field side, and vanishes when flux-surface averaged. However, XGC1 finds that the ballooning nature of the ITG turbulence preferably transports the co-current directional edge Pfirsch-Schluter flow into core. The orbit loss mechanism reinforces the co-current directional edge momentum generation. The neoclassical nature of the edge rotation source and the turbulence nature of the inward momentum transport have been verified by repeating the same simulation in the pure neoclassical mode: In this case, the edge rotation source remains, but the inward momentum transport vanishes. Detailed analysis showed that the residual stress from the ITG turbulence is responsible for the inward momentum transport. Validation with a DIII-D experimental result [S. Muller, Phys. Plasmas 2011] shows that the finding from XGC1 is in the right ballpark for both the edge rotation profile and the inward transport time scale.

B. Tang participated in a meeting of the G8 NuFuSE Project sponsored in the U.S. by NSF, which provided the support for attending this conference. The key news at ISC-2013 centered on the official Top 500 announcement of the new number one supercomputer in the world, China's TH-2 Intel-MIC based system. Delivering a theoretical peak of nearly 55 TF, TH-2 more than

doubled the capability of the previous top-rated Titan GPU-based system at the Oak Ridge National Laboratory. An associated link providing details of this impressive achievement can be found at: http://www.hpcwire.com/hpcwire/2013-06-17/top_500_results_reveal_global_acceleration_balance_shift.html

This week's theory seminar titled "Energetic Consistency and Symmetry in Gyrokinetic Field Theory" was presented by Dr. Bruce Scott from Max-Planck-IPP. Dr. Scott presented his theoretical model for gyrokinetic field theory. Global and local toroidal momentum conservations were obtained. Momentum fluxes were calculated using flux tube and global gyrofluid models. It was shown that higher order fluxes are small correction and lowest order terms plus FLR corrections are adequate for momentum transport. The abstract of the talk is: The theorem for toroidal angular momentum conservation within gyrokinetic field theory is used as a starting point for detailed statistical analysis of the momentum fluxes as computed by gyrofluid and gyrokinetic models. Fluxtube and radially finite cases are considered within different representations of magnetic field-aligned geometry. The simple two-dimensional Hasegawa-Wakatani (HW) drift-wave turbulence model is used as a control case. In geometrically symmetric cases the fluxes average to zero, but only in the statistical sense of an ensemble average. In global gyrofluid cases the self consistent flow equilibrium provides a small symmetry breaking, allowing for a finite intrinsic momentum flux in the absence of a seed flow, driven solely by thermal gradients. The main result is that the symmetry properties of both low- and high-order fluxes are similar, so that the effect of high-order fluxes remains a small correction to the usual results."

COMPUTATIONAL PLASMA PHYSICS GROUP (S. JARDIN):

Dr. Taisuke Boku from the Center for Computational Sciences, University of Tsukuba, presented a CPPG seminar on "HA-PACS Project with Tightly Coupled GPU communication and XMP Programming Language". The CCS (Center for Computational Sciences) is developing a large scale GPU cluster named HA-PACS with 802 TFLOPS peak performance plus a specially enhanced additional 330 TFLOPS supported by a special hardware/software feature named TCA (Tightly Coupled Accelerators) Architecture. TCA is a novel solution to provide very fast and low latency GPU-GPU direct communication to speed-up various scientific codes. They also are developing a language named XcalableMP-dev (XMP-dev), which provides features to describe large scale scientific codes in easy and suitable way for large scale GPU clusters. GTC-P is selected as the first practical application code to run on this framework. This project is still underway, but the speaker summarized status and near term plans.

ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):

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

Construction: The MPTS platform modifications have been completed. The lower PF4/5 clamp upgrades continue. Aluminum castings and outer support structure clamps were installed on TF14. TF14 has been installed on NSTX. TF13 is having a water leak repaired and it should be installed next week. The re-installation of conduits, trays and racks is just getting underway.

CS Upgrade: The last quadrant was removed from the mold and passed the meggar tests. The lab now has four completed and tested quadrants ready to go onto the next phase of the centerstack assemble, TF full mold VPI. The full mold was released for shipment and is expected to arrive in the coil winding area early next week. The completed quadrants are now being prepared for the full mold VPI by removing resin rich areas and roughening the surface to improve bonding with the resin. The OH winding fixture tensioning table fabrication continues in the Tech Shop. The buss bar models have been handed off to analysis group for final design analysis verification. Some interference in the model discovered by analysis group has been corrected in the models. We should be able to continue analysis on the TF, OH, and PF1a,b&c Bus Bars. The copper procurement requisition was approved and submitted. We will continue to work on with procurement to keep it on track.

NBI Upgrade: Installation of the water manifolds on the source platform continues and nears completion. Fabrication and leakchecking of LHe and LN cryo line continues in the NB shop. LHe cryogenics line installation, welding, and leakchecking on the TFTR Test Cell East wall continues. TTC HVAC duct reinstallation is in progress. Fabrication and welding continues on the NB/TVPS duct and bellows shield components in the Tech Shop. The DI water system subcontract continues with pipe fitting, welding, and installations in the Pump Room. The power system cable and tray requisition has been processed. Drafting work on NTC power cable and tray drawings continues. JK VV reinforcements and SFLIP pieces are on order. LCC Controls work continues.

BUSINESS OPERATIONS (K. FISCHER):

The Procurement Division has assumed responsibility for reviewing requisitions for printing and printed materials, and for obtaining these items through the Government Printing Office (GPO) in accordance with the Printing and Binding Regulations published by Congress. Previously, this function was performed by the Communications Office. Effective immediately, inquiries regarding the purchase of printing should be directed to Chandra Sanders, Procurement Analyst, at extension 3254, email csanders@pppl.gov.

OFFICE OF COMMUNICATIONS: (K. MACPHERSON):

A story by DeVoe that also featured photography by E. Starkman about a collaboration between PPPL and Princeton University art students was featured on the Princeton homepage: http://www.princeton.edu/main/news/archive/S37/17/37O32/index.xml?section=topstories. DeVoe also edited materials presented at the Service Awards ceremony June 18.

J. Greenwald and DeVoe participated in an Office of Science conference call for science communications officers of national laboratories on June 20. J. Greenwald also posted PowerPoint presentations for MINDS and the Theory Department's TRANSP code on the DOE's Lab Discovery website, and worked with a vendor on printed material accompanying the new NSTX-U and Quasar displays in the LSB lobby.

OFFICE OF ACADEMIC AFFAIRS (N. FISCH):

N. Fisch visited ASIPP in Hefei, China, giving two talks. On June 19, he gave a lecture on "Methods of RF Current Drive". On June 20, he gave a lecture on "Some Unsolved Problems in RF Heating and Current Drive."

DIRECTOR'S OFFICE (C. AUSTIN):

M. Zarnstorff visited Boeing in St. Louis, Missouri on June 19-20 to discuss opportunities for collaboration.

INVITED TALKS:

Bill Tang presented an invited talk on "Supercomputing Grand Challenges and Advances in Fusion Energy Simulations" in a featured session chaired by Jack Dongarra at the International Supercomputing Conference (ISC-2013) in Leipzig, Germany.

PUBLICATIONS:

The paper "Observation of non-Maxwellian Electron Distributions in the NSTX Divertor" by M.A. Jaworski (PPPL), et al., has been published in the Journal of Nuclear Materials (vol. 438 pp.S384-S387). It describes measurements and analysis of the NSTX divertor indicating kinetic effects are generating energetic tail populations. The Langmuir probe interpretation of the bulk population of electrons is consistent with spectroscopic measurements and modeling of the hydrogen emission. These results are consistent with previous analytical and modeling studies indicating kinetic effects should be expected in steep-gradient regions of the plasma.

The paper "Characterization of Fueling in NSTX H-mode Plasmas Diverted into a Liquid Lithium Divertor" by R. Kaita (PPPL) et al., has been published in the Journal of Nuclear Materials (vol. 438 pp.S488-S492). It discusses observations from deuterium fueling experiments with the NSTX Liquid Lithium Divertor (LLD). In plasmas with the diverted outer strike point on the LLD, high values of applied deuterium gas input relative to the deuterium plasma content were achieved without disrupting the plasma. Under constant deuterium fueling, the deuterium retention by the LLD remained relatively unchanged, as its surface temperature varied from below to above the lithium melting point. The results from both experiments indicated performance improvement over discharges where graphite plasma-facing components were not lithium coated. Their interpretation is complicated, however, by the possibility of lithium compound formation and the deposition of eroded carbon on the LLD surface.

The paper "Response of NSTX Liquid Lithium Divertor to High Heat Loads" by T. Abrams (Ph.D. Thesis Student, Princeton University) et al., has been published in the Journal of Nuclear Materials (vol. 438 pp.S313-S316). It describes the results of an experiment in which samples of the NSTX Liquid Lithium Divertor (LLD) were directly exposed to a neutral beam ex-situ at power densities of 1.5 MW per square meter for up to 3 seconds with and without a lithium

coating. The lithium-coated sample developed a lithium hydroxide layer that did not change even when the front face temperature exceeded the pure lithium melting point. These results imply that heating alone may not expose pure liquid lithium to the plasma if the melting point of surface impurities is not exceeded. It suggests that flow and heat may be needed for future plasma-facing components requiring a liquid lithium surface.

A paper entitled "Field-line Resonance Structures in Mercury's Multi-ion Magnetosphere" by E.-H. Kim, J.R. Johnson, D.-H. Lee, and Y.S. Pyo has been published on Earth Planet and Space.

The following PPPL Reports were posted to the web:

ITER Power Supply Innovations and Advancements PPPL-4901
Authors: C.L. Neumeyer, et. al.
Submitted to: SOFE 2013 Proceedings (June 0213) 25th Symposium on Fusion Engineering, San Francisco, CA (June 10-14, 2013)

Electromagnetic and Structural Analyses of the ITER Central Solenoid Feeder Structures PPPL-4902
Authors: A.M. Zolfaghan and K. Freudenberg
Submitted to: SOFE 2013 Proceedings (June 0213) 25th Symposium on Fusion Engineering, San Francisco, CA (June 10-14, 2013)

Electron-scale Turbulence Spectra and Plasma Thermal Transport Responding to Continuous ExB Shear Ramping-up in a Spherical Tokamak PPPL-4903
Authors: Y. Ren, et. al.
Submitted to: Nuclear Fusion (December 2012)

NSTX-U Digital Coil Protection System Software Design PPPL-4904
Authors: Keith G. Erickson, Gregory J. Tchilinguirian, Ronald E. Hatcher, William M. Davis
Submitted to: SOFE 2013 Proceedings (June 0213) 25th Symposium on Fusion Engineering, San Francisco, CA (June 10-14, 2013)

Practicality of a Plasma Mass Filter for Nuclear Fuel Reprocessing: Separating Lanthanides from Actinides PPPL-4905
Authors: R. Gueroult and N.J. Fisch
Submitted to: IEEE Pulsed Power and Plasma Science (PPPS2013) June 16-21, 2013 San Francisco, CA

Tendency of a Rotating Electron Plasma to Approach the Brillouin Limit PPPL-4906
Authors: Renaud Gueroult, Amnon Fruchtman and Nathaniel J. Fisch
Submitted to: Physics of Plasmas (May 2013)

Heating and Current Drive Requirements towards Steady State Operation in ITER PPPL-4907
Authors: F.M. Poli, P.T. Bonoli, C.E. Kessel, D.B. Batchelor, M. Gorelenkova, B. Harvey and Y. Petrov
Submitted to: 20th Topical Conference on Radio Frequency Power in Plasmas, Sorrento, Italy, June 25-28, 2013

Flowing Liquid Lithium for the Purpose of Reducing Tritium Inventory Levels in Fusion Energy Reactors PPPL-4908
Authors: Charles A. Gentile, et. al.
Submitted to: SOFE 2013 Proceedings (June 0213) 25th Symposium on Fusion Engineering, San Francisco, CA (June 10-14, 2013)

Digital Coil Protection System I/O and Data Subsystem for NSTX-U PPPL-4909
Authors: Gregory J. Tchilinguirian, Keith G. Erickson and Ronald E. Hatcher
Submitted to: SOFE 2013 Proceedings (June 0213) 25th Symposium on Fusion Engineering, San Francisco, CA (June 10-14, 2013)

Radial Cooling of a Spherical Torus (ST) Toroidal Field (TF) Centerpost PPPL-4910
Authors: Robert D. Woolley
Submitted to: SOFE Proceedings (June 0213) 25th Symposium on Fusion Engineering, San Francisco, CA (June 10-14, 2013)

SPIRAL Field Mapping on NSTX for Comparison to Divertor RF Heat Deposition PPPL-4911
Authors: Joel Hosea, et. al.
Submitted to: 20th Topical Conference on Radio Frequency Power in Plasmas, Sorrento, Italy, June 25-28, 2013)

Fast Wave Heating in the NSTX-Upgrade Device PPPL-4912
Authors: Nicola Bertelli. et. al.
Submitted to: 20th Topical Conference on Radio Frequency Power in Plasmas, Sorrento, Italy, June 25-28, 2013)

Numerical Analysis and Optimization of Divertor Cooling System PPPL-4913
Authors: Andrei Khodak and Michael A. Jaworski
Submitted to: SOFE 2013 Proceedings (June 0213) 25th Symposium on Fusion Engineering, San Francisco, CA (June 10-14, 2013)

Eddy Current and Gap Voltage at Electrical Contacts of ITER Diagnostic First Walls and Shield Modules during Plasma Disruptions PPPL-4914
Authors: Yuhu Zhai, et. al.
Submitted to: 20th Topical Conference on Radio Frequency Power in Plasmas, Sorrento, Italy, June 25-28, 2013)

Finite- β Simulation of Microinstabilities PPPL-4915
Authors: Edward A. Startsev and W.W. Lee
Submitted to: Physics of Plasmas (June 2013)

Development of Steady-State Mirrors for the KSTAR ECH Launchers PPPL-4916
Authors: R. Ellis, Y.S. Bae, J. Hosea, M. Joung, D. Miller, W. Namkung and H. Park
Submitted to: SOFE 2013 Proceedings (June 0213) 25th Symposium on Fusion Engineering, San Francisco, CA (June 10-14, 2013

Towards Identifying the Mechanisms Underlying Field-Aligned Edge-Loss of HHFW Power on NSTX PPPL-4917

Authors: Rory Perkins, et. al.
Submitted to: 20th Topical Conference on Radio Frequency Power in Plasmas, Sorrento, Italy, June 25-28, 2013

Fast-wave Power Flow Along SOL Field Lines In NSTX and The Associated Power Deposition Profile Across The SOL In Front Of The Antenna PPPL-4918

Authors: Rory Perkins, et. al.
Submitted to: Nuclear Fusion (December 2012)

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