

PRINCETON PLASMA PHYSICS LABORATORY

WEEKLY highlights



The PPPL Highlights for the weeks ending December 20, 2013 and January 3, 2014, are as follows:

NSTX (M. ONO):

F. Scotti successfully defended his doctoral dissertation entitled "Modifications of Impurity Transport and Divertor Sources by Lithium Wall Conditioning in the National Spherical Torus Experiment" on December 19. His advisors were Vsevolod (Vlad) Soukhanovskii of the Lawrence Livermore National Laboratory and R. Kaita of PPPL. Scotti used data from an extensive set of diagnostics, including visible camera systems he implemented, to study the behavior of impurities in the NSTX divertor region. He observed that lithium evaporated into the lower divertor region resulted in a lower carbon-sputtering yield. This effect, however, can be counteracted by weaker impurity retention because of the reduced recycling associated with lithium, and carbon sources that the graphite NSTX walls present. Scotti also conducted an extensive investigation of core impurity transport. He showed that ELM suppression and changes in neo-classical transport can explain the core carbon accumulation in H-mode plasmas with lithium evaporation. While the presence of carbon can also lead to enhanced lithium particle diffusivities, this does not provide a complete explanation for the low core lithium concentrations. Such issues will be the focus of further research in NSTX-U.

A paper entitled "Intrinsic rotation generation in NSTX ohmic H-mode plasmas" by J.-K. Park (PPPL) et al, has been published in Nuclear Fusion. This work reported intrinsic rotation generation observed in NSTX ohmic plasmas, by uniquely utilizing passive views of charge exchange recombination diagnostics (R. E. Bell). Results indicated that intrinsic rotation generation in the edge is well correlated with ion temperature gradient change. This is consistent with a corresponding theory of residual stress by P. H. Diamond and Y. Kosuga, as a quantitative comparison was successfully made between the measured torques with the predicted ones. However, it was discussed that an uncertainty on the order of diamagnetic rotation can exist in many places across measurement and theory in general, which should be further resolved to predict the intrinsic torque and rotation in the next-step devices such as ITER.

A paper "Turbulence-induced diffusion analysis of national Spherical Torus Experiment based on the gyrocenter shift", by K.C. Lee (NFRI, Daejeon, Korea), et al., was published in Journal of the Korean Physical Society. The paper describes a confinement time deterioration proportional to the square of density fluctuation and electron temperature measured in the edge region of the NSTX plasmas. The experimental measurement showed an agreement with the turbulence induced diffusion coefficient based on the gyrocenter shift (GCS) theory.

Dan Boyer, a recent Ph. D. recipient from the Lehigh University Department of Mechanical Engineering and Mechanics, began a two-year ORISE post-doctoral fellowship at PPPL on December 16. Boyer's fellowship proposal was entitled "Feedback Control and Optimization of the Current Profile for NSTX-Upgrade". He will be working with D. Gates (PPPL) and others on implementing his ideas for current profile control on NSTX-U.

ITER & TOKAMAKS (R. HAWRYLUK):

R. Hawryluk chaired a session "Plasma Scenarios and Control" at the IAEA Workshop on DEMO held in Vienna, Austria. The gaps between ITER and DEMO were identified at this meeting.

DIII-D (R. Nazikian)

A. Nagy worked with an ORNL technician to understand and refine the induction-brazing machine at DIII-D after replacing capacitors in the brazing head to obtain the correct resonant circuit. Four de-brazes were performed on the bench to establish induction brazing parameters. This will be used to de-braze and save parts of the IU90 I-coil inside DIII-D that was inoperable due to a ground fault this year.

R. Maingi and John Canik (ORNL) continued analysis of VH-mode discharges in DIII-D, originating from a dedicated experiment earlier in the year. The edge profiles, transport and stability in VH-modes are being compared with similar assessments of Enhanced Pedestal H-modes from NSTX. Both operational modes benefit from high rotational shear for achievement of high pedestal temperatures and gradients.

ADVANCED PROJECTS (H. NEILSON):

H. Neilson visited the Max Planck Institute for Plasma Physics (IPP) in Greifswald, Germany, December 12-13 in connection with the U.S. collaboration on Wendelstein 7-X (W7-X). Task agreements covering collaborative work for 2014 were reviewed with W7-X program leaders T. Klinger and H.-S. Bosch. The tasks consist of: scraper element design, X-ray imaging crystal spectrometer, extended assignment of U.S. staff to IPP, magnetics and control, and infrared Imaging. After a final review of the task agreements by U.S. task leaders, they will be submitted for approval by DOE and IPP.

The safety disconnect switches for the U.S.-supplied trim coil system on Wendelstein 7-X were delivered to the project site; IPP colleagues reported that installation of the switches has begun, the first step in the installation of the trim coil electrical equipment. Regarding the coils themselves, four of the five are installed on the W7-X device; the fifth has been prepared and is ready for installation at the appropriate point in the W7-X assembly sequence.

In the Laboratory's collaboration with the Large Helical Device (LHD) project at Japan's National Institute for Fusion Science (NIFS), N. Pablant reported completing the installation of U.S. data analysis software on NIFS computers. With this step, Pablant completed a successful 3-month visit to NIFS to participate in the 2013 LHD experimental campaign. Said NIFS x-ray

group leader S. Morita, "The data analysis on XICS [x-ray imaging crystal spectroscopy] will be very exciting, in addition to the poloidal rotation and the data from single-chord XCS. I would like to express my sincere gratitude for your effort during this year's LHD experimental campaign." A manuscript based on data obtained in the 2012 campaign is being prepared for publication. Subsequent publications based on the 2013 data are planned.

H. Neilson attended the Second IAEA DEMO Programme Workshop (DPW), held 17-20 December at IAEA Headquarters in Vienna, Austria. Topics for this year's workshop consisted of: 1. fusion design codes; 2. plasma power exhaust; and 3. plasma scenarios and control. Highlights of U.S. contributions included a report by C. Kessel on the ARIES comparison of tokamak designs using aggressive and conservative assumptions, a proposed roadmap for divertor and plasma-material interaction research by D. Hill (LLNL), a report on ITER steady-state plasma simulations by F. Poli, and report by A. Garofalo (GA) discussing how heating and current drive technology choices impact the design of steady state scenarios. Neilson attended a meeting of the program committee, in which plans for the third DPW, to be held in China in the Spring of 2015, were developed.

THEORY (A. BHATTACHARJEE):

This week's theory seminar of this year was presented by Professor Eliezer Hameiri from New York University, entitled "Multi-fluid and MHD plasmas with flow, a variational approach". The abstract of the talk is "Based on an extension to plasmas of Ertel's classical vorticity theorem in fluid dynamics, it is shown that for each species in a multi-fluid plasma there can be constructed a set of nested surfaces that have this species' fluid particles confined within them. Variational formulations for the plasma evolution and its equilibrium states are developed, based on the new surfaces and all of the dynamical conservation laws associated with them. A limit of the variational integral yields the two-fluid Hall-Magnetohydrodynamic (HMHD) model. A further special limit yields MHD equilibria and can be used to approximate the equilibrium state of a Hall-MHD plasma in a perturbative way."

COMPUTATIONAL PLASMA PHYSICS GROUP (S. JARDIN):

The CY2014 NERSC computer time allocation awards for PPPL were announced this week. The PI's, Projects, and awards (in millions of core hours) were: A. Bhattacharjee, "Center for Integrated Computation and Analysis of Reconnection and Turbulence", 5M; S. Cohen, "FRC simulations with the Lsp PIC code: 10M; R. Davidson, "Simulations of Field-Reversed Configuration and Other Compact Tori Plasma": 0.070M; S. Jardin, "Study of the Internal Dynamics of ITER", 13M; S. Jardin, "3D Extended MHD Simulation of Fusion Plasmas", 20M; W. Lee, "Turbulent Transport and Multiscale Gyrokinetic Simulation, 25M; D. Mikkelsen, "Experimental Tests of Gyrokinetic Simulations of Microturbulence", 15M; W. Wang, "Investigation of Plasma Rotation Inversion and Profile Structure in Magnetic Fusion Experiments", 3.2M.

ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):

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

Construction: Torquing of the upper outer TF support weldments to their final torque levels has been completed for all except Bay L. The torquing of lower weldments is in progress. Work on the centerstack casing studs continues in the south high bay of the NSTX Test Cell. In vessel work will resume next week.

The centerstack casing was moved to the south high bay of NSTX and work continues on the mounting studs. The in-vessel diagnostic cables were rerouted, bay D/E top flange inspections occurred, and Mirnov coils were installed. The vacuum vessel feet reinforcements are complete. PF4/5 supports at all but bays B and L are complete. Thermal transfer caulk is being installed between the bakeout tubing and the vessel. The glow discharge cables are being installed and terminated.

CS Upgrade: During the holiday break, the winding team successfully wound the first several turns with the diameter meeting the requirements. The conductor is now slightly twisting so several corrective clamps are presently being made by the machine shop before winding resumes. The new clamps will hold the conductors together and reduce any twisting. The tensioning unit and taping heads are working fine, and based on conductor that has been wound, the conductor is conforming nicely to the bundle. Everson has reported they potted and cured the first PF1B coil. Upon their inspection, it was noted a small epoxy dry area near the leads. The plan is to rework the area using the same method used on the W7X coils. Everson was asked to generate a NCR with rework plan for approval by PPPL. The coil successfully passed electrical, hydro, and flow tests. The second PF1B coil is ready to set leads and begin winding next week.

The first termination and two water fittings were brazed onto layer 1 of the OH coil. The first turn has been anchored and the OH winding process has commenced. Several days are scheduled over the holidays to continue OH winding. The first PF1B coil was epoxy potted at Everson. The cure cycle will be conducted over the weekend and removal from the mold is planned for December 26. Coils bus work continued this week. Rough machining of the TF Bundle G10 crown interface connection was completed in the Tech Shop.

NBI Upgrade: Progress on DI water manifold installations continued but slowed due to restrictions in the area during cable pulling operations. The NBI Armor assembly and TC installations took place this week and after a cure cycle the armor was installed in the vacuum vessel. Work continues on the subcontract cable installation. Three cables were pulled into the NTC. Setup for pulling more cables into the TCB took place and after a quick turn around pulling resumed. Additional water system parts have been received. NBI work continued through the holiday break on select days.

BUSINESS OPERATIONS (K. FISCHER):

PPPL executed a Work for Others Agreement with the ITER Organization for a project titled "Heating and Current Drive Analysis for the Electron Cyclotron System." C. Kessel is the Principal Investigator. The budget is \$360,000 for the three-year period of performance.

INFORMATION TECHNOLOGY (S. BAUMGARTNER):

The NSTX-U Digital Coil Protection System's "Auto-Tester" was used for the first time to generate timing and 'coil current' signals to the DCPS real-time computer.

The paper "NSTX-U Control System Upgrades" by K. Erickson (et al) was recommended for publication in an upcoming issue of Fusion Engineering and Design.

DIRECTOR'S OFFICE (C. AUSTIN):

On December 16, S. Prager attended a National Laboratory Director's Council meeting in Washington, DC, hosted by DOE Secretary Moniz.

On December 16, the PPPL Research Meeting was chaired by S. Kaye - the agenda items were: Research introduction by M. Zarnstorff, Alison Waldron (AIP): Data Accessibility: The Role of the Publisher, and Mark Martin (DOE/OSTI): Dataset Citation: From Pilot to Production.

On December 18, Dr. R. Majeski, Princeton University, presented a colloquium entitled, "The Lithium Tokamak eXperiment (LTX)".

PUBLICATIONS:

Park, J.-K.; et al, "Intrinsic rotation generation in NSTX ohmic H-mode plasmas," Nuclear Fusion 53 (2013) 063012.

Lee, K.C. (NFRI, Daejeon, Korea); et al., "Turbulence-induced diffusion analysis of national Spherical Torus Experiment based on the gyrocenter shift," Journal of the Korean Physical Society, 63, 2102 (2013).

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