PRINCETON PLASMA PHYSICS LABORATORY
WEEKLY highlights

PPPL
U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending November 22, 2013, are as follows:

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

Representatives from Siemens visited PPPL for technical meeting concerning ITER HV and Control and to discuss Quality Plan.

In a telecon with the ITER Organization, it was agreed that dedicated Quality Plans will not be required for Steady State Electric Network procurements, and Manufacturing and Inspection Plans are also not required in most cases.

An internal PPPL 'Peer Review' of US ITER diagnostic integration activities was held, with several PPPL engineers not involved in these activities commenting on challenging issues.

A biweekly coordination meeting, involving the US-DA, IO, and IN-DA, discussed the interface between the US and the IN parts of the ECE diagnostic system, with particular focus on the region between the vacuum windows on the port plug (US) and the polarization splitter boxes located in the interspace region (IN). The IN-DA proposed to provide a shutter, operating outside the vacuum, to protect the downstream components from stray, high-power microwave radiation.

A draft Statement of Work was placed in review for a prototype retroreflector for the Toroidal Interferometer/Polarimeter (TIP) diagnostic.

A proposal has been made to modify the JET reflectometer in a way to allow comparison of simultaneous measurements of the density profile with a mono-static and a bi-static configuration. The simpler mono-static approach was successfully demonstrated last year on DIII-D, and is now proposed for the ITER Low-Field-Side Reflectometer (LFSR) design. Recent analysis results on heating of the LFSR windows due to stray ECH power and on heating of the plasma-facing antennas was presented in a monthly progress meeting with experts at ITER.

An experimental proposal was approved to gather precision spectroscopy data in optimum conditions on JET to resolve the motional Stark splitting of the beam emission. This data would then be used to constrain the plasma equilibrium, first with L. Zakharov's ESC code and then with EFIT. This approach is being proposed for ITER, where higher values of the toroidal field and beam energy favor its use. Similar validation activities are being investigated that would use a precision spectroscopy system on DIII-D along with modifications to EFIT.

NSTX (M. ONO):

Several NSTX-U researchers presented results at the Workshop on MHD Stability Control held in Santa Fe, New Mexico during November 18-20. J. Menard (PPPL) presented “Kinetic effects on the ideal-wall limit and the resistive wall mode”, Jack Berkery (Columbia University) presented “Resistive Wall Mode Stability in NSTX and Benchmarked Kinetic Physics Calculations with MISK”, Steve Sabbagh (Columbia University) presented “Active resistive wall mode and plasma rotation control for disruption avoidance in NSTX-U”, Y-S. Park (Columbia University) presented “Resistive Wall Mode Active Control Physics Design for KSTAR”, E. Fredrickson (PPPL) presented “Energetic particle instabilities and their control in steady state plasma”, Z. Wang (PPPL) presented “The Use of DCON for Computation of Outer Region Matching Data for Singular MHD Modes in Axisymmetric Toroidal Plasmas”, and K. Kim (PPPL) presented “Study on neoclassical transport and kinetic stability in perturbed tokamaks with particle simulation”. Lastly, L. Delgado (PPPL) presented “Internal kink modes in Ohmic and LHCD plasmas in Alcator C-Mod”

W. Guttenfelder (PPPL), Antoine Cerfon (Courant Institute, NYU) and Zach Hartwig (MIT, PSFC) attended the Kavli Frontiers of Science Symposium hosted by the National Academy of Sciences, November 7-9, Irvine, Califronia (http://www.nasonline.org/programs/kavli-frontiers-of-science/past-symposia/2013-usfos.html). The aim of the symposium is "to bring together young scientists to discuss exciting advances and opportunities in a broad range of disciplines". The three presented a session (proposed by Anne White, MIT and Cerfon) entitled "Progress in bringing a star to earth", with the aim of summarizing some of the accomplishments and remaining challenges for magnetic fusion energy. After an introduction (Cerfon), two talks were given: "Understanding and controlling turbulence at 100 million degrees" (Guttenfelder) and "Enclosing a star: The challenges of materials in magnetic fusion energy" (Hartwig). A number of interesting questions and comments were given during the 45-minute discussion session following the talks.

Dr. Dmitri Ryutov (Lawrence Livermore National Laboratory) visited PPPL on November 21 – 22. He gave a talk entitled "Novel divertors based on manipulation of poloidal field structure". The talk summarized recent theoretical progress in developing divertor magnetic field geometries with poloidal field nulls of the first, second and third order, understanding of their magnetic and plasma properties, and comparison with experiments on DIII-D, NSTX and TCV. Dr. Ryutov also met with several NSTX-U and PPPL staff and discussed a variety of fusion, laboratory and astrophysical plasma physics topics.

Tom Williams, a graduate student from the University of York in the United Kingdom who is completing his doctoral research, visited PPPL on November 18 and 19. He presented a seminar entitled "Propagation in 3D of microwaves through density perturbations" at the NSTX-U Monday physics meeting on November 18 and visited various members of the PPPL research staff during his visit. He is helping to analyze data obtained with the Synthetic Aperture Microwave Imaging (SAMI) diagnostic on MAST. The SAMI diagnostic will be moved from MAST and installed on NSTX-U next year as part of a collaboration with the University of York and the Culham Centre for Fusion Energy, allowing us to study in detail the electron Bernstein wave mode conversion physics in the edge of NSTX-U.

Gustavo Canal, a graduate student from EPFL (Swiss Federal Institute of Technology in Lausanne, Switzerland), visited PPPL on November 22. He presented a seminar entitled "Fast seeding of NTMs by sawteeth and the use of non-continuous ECRH for their preemption," and also met with several NSTX and PPPL researchers.

Bilel Rais, a graduate student from Consorzio RFX, Italy will be visiting PPPL from November 18 – December 21. The purpose of this visit is to collaborate with C. Skinner of PPPL and Bruce E. Koel (Professor of Princeton University) on surface analysis of plasma facing materials to understand the characteristics of boronized and lithiated samples exposed and unexposed to RFX-mod plasma discharges.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

E. Kolemen presented an invited talk "Neoclassical tearing mode control and stabilization in steady state burning plasma" at the MHD Workshop in Santa Fe, New Mexico. M. Okabayashi presented a talk at the same workshop on "2/1 NTM disruption control by applied electromagnetic toque."

A paper entitled "Simulation of localized fast-ion heat loads in test blanket module simulation experiments on DIII-D" by Gerrit Kramer *et al.* was recently published in Nuclear Fusion. Abstract: Infrared imaging of hot spots induced by localized magnetic perturbations using the test blanket module (TBM) mock-up on DIII-D is in good agreement with beam-ion loss simulations. The hot spots were seen on the carbon protective tiles surrounding the TBM as they reached temperatures over 1000 °C. The localization of the hot spots on the protective tiles is in fair agreement with fast-ion loss simulations using a range of codes: ASCOT, SPIRAL and OFMCs while the codes predicted peak heat loads that are within 30% of the measured ones. The orbit calculations take into account the birth profile of the beam ions as well as the scattering and slowing down of the ions as they interact with the localized TBM field. The close agreement between orbit calculations and measurements validate the analysis of beam-ion loss calculations for ITER where ferritic material inside the tritium breeding TBMs is expected to produce localized hot spots on the first wall.

A. Nagy and DIII-D technical staff members are making progress on developing an induction heater to dismantle an I-coil in the DIII-D vacuum vessel. The plan is to repair the shorted in-vessel I-coils in situ. In this regard, two short locating techniques were further refined to identify precisely where in the single turn coil the short occurred. One method uses an electrical test signal method while the other used an IR camera. The plan is to repair the coils during the vent in preparation for the restart of the experimental campaign.

ADVANCED PROJECTS (H. NEILSON):

In the Laboratory's collaboration with Japan's Large Helical Device (LHD) stellarator program, PPPL physicist N. Pablant led an experiment to investigate in detail how the level of heating

power affects the transport properties of electron cyclotron-heated (ECH), high electron-temperature discharges. In the experiment, the ECH power was scanned from 2MW to 3MW in steps of 0.2 MW. The United States x-ray imaging crystal spectrometer (XICS) diagnostic provided both ion temperature and poloidal rotation measurements. Clear differences in both the ion temperature profile and the poloidal rotation were seen at the different ECH power levels. In particular the formation of a highly peaked electron temperature profile was only seen at the highest ECH powers. Data from this experiment are being analyzed to elucidate the transition dynamics between different transport modes (i.e. from ion root to electron root) in this regime.

In its collaboration with South Korea's National Fusion Research Institute (NFRI), the Laboratory hosted a K-DEMO project meeting, attended by study team members from NFRI, PPPL, and the University of Texas at Austin (UTA). The PPPL team reported progress in machine configuration development, focusing on maintenance, tritium breeding, cooling, and support considerations. The NFRI reported progress in developing a blanket model in preparation for neutronics analyses to estimate tritium breeding ratio and shielding performance. The UTA group reported on their studies of advanced divertor configurations for K-DEMO, as an option for future design updates. Agreement was reached on PPPL work priorities for the next few months. It was agreed that PPPL would submit a report of its work to NFRI in March 2014, including contributions to a K-DEMO Conceptual Studies Report that the NFRI team will issue in mid-2014. PPPL's work on this collaboration is funded by NFRI on a work-for-others basis.

Advanced Projects work was represented in several papers at the Meeting of the APS Division of Plasma Physics in Denver, Colorado. Papers included "Applications of 3D Equilibrium Reconstruction," by S. Lazerson *et al.*; "Linear Stability and Quasilinear Particle & Heat Fluxes in Ion--ITB Plasmas in LHD," by D.R. Mikkelsen, *et al.*; and "The QUASAR (QUASi-Axisymmetric Research) Facility," by D. Gates, *et al*.

THEORY (A. BHATTACHARJEE):

J. Johnson and E.H. Kim attended an electromagnetic ion cyclotron (EMIC) wave workshop at the University of New Hampshire on November 13-14. J. Johnson suggested that the ion-ion hybrid (IIH) resonance can explain magnetospheric compressional waves, which are newly detected by Van Allen probes, and E.H. Kim showed how the IIH resonance can have narrow bandwidth with magnetic compressional components using numerical simulations. They also suggested that mixed polarized EMIC waves could be generated by external sources rather than by locally generated instabilities.

Dr. Chung-Sang Ng (University of Alaska) gave a talk entitled "MHD Simulations of the Parker Model of Solar Coronal Heating" for Helio-seminar on November 19. Using new scaling results based on 2D and 3D reduced MHD simulations, he discussed the Parker model which is one of most discussed mechanism of solar coronal heating. His presentation has been posted on http://helio.pppl.gov.

This week, two theory seminars were presented. On November 21, the seminar was presented by Dr. J. Perez from University of New Hampshire entitled "Direct Numerical Simulations of Reflection-Driven, Reduced MHD Turbulence from the Sun to the Alfvén Critical Point". The

abstract of this talk is "We present a numerical study of the fundamental properties of reflection-driven Alfven Wave (AW) turbulence and its applications to the extended solar atmosphere, using realistic profiles that account for the inhomogeneities in density, background flow, and the background magnetic field present in coronal holes. The simulations are performed inside a narrow magnetic flux tube extending from the base of the solar corona to about eleven solar radii. The simulation results address the radial dependence of turbulence spectral slopes, energy cascade rates as well as other important turbulence characteristics in the context of existing phenomenological models and remote observation. "

The second theory seminar on November 22 was presented by Dr. F. Halpern from Center for Research in Plasma Physics, Ecole Polytechnique Federale de Lausanne, entitled "A theory for the scrape-off layer width in inner-wall limited plasmas". The abstract reads "We develop a predictive theory applicable to the scrape-off layer (SOL) of inner-wall limited plasmas. Using the non-linear flattening of the pressure profile as a saturation mechanism for resistive ballooning modes, we are able to demonstrate and quantify the increase of the SOL width with plasma size, connection length, plasma beta, and collisionality. Individual aspects of the theory, such as saturation physics, parallel dynamics, and system size scaling, are tested and verified using non-linear, 3D flux-driven SOL turbulence simulations. Altogether, good agreement between theory and simulation is found."

A. Reiman organized a lunchtime satellite meeting at APS on cross-benchmarking of codes for calculating 3D equilibrium solutions for DIII-D plasmas. The participants discussed plans for benchmarking activities, and they agreed on a set of specifications for data files from the codes to be used for comparison of equilibrium solutions. There are 11 codes participating in the benchmarking activity: the linearized equiilibrium codes IPEC (J-K Park) and MARS (Turnbull), the time-dependent extended MHD codes M3D-C1 (Ferraro), M3D (Breslau), and NIMROD (Sovinec, Zhu), the guiding center particle code XGC0 (Chang, Hager), as well as VMEC (Lazarus, Lazerson), NSTAB (Garabedian's code: Cerfon, McFadden), PIES (Reiman), HINT (Suzuki in Japan) and SPEC (Hudson). The names in parentheses are the people running the codes for this exercise.

COMPUTATIONAL PLASMA PHYSICS GROUP (S. JARDIN):

J. Lang and S. Ethier attended the SC13 International Conference for High Performance Computing, Networking, Storage, and Analysis. Both Drs. Lang and Ethier were co-authors on a poster presentation entitled "Hybrid MPI/OpenMP/GPU Parallelization of XGC1 Fusion Simulation Code" (Eduardo F. D'Azevedo {ORNL}, J. Lang {PPPL}, Patrick H. Worley {ORNL}, S. Ethier, S.H. Ku, C.S. Chang {PPPL}). Ethier was also a co-author on a talk entitled "Kinetic Turbulence Simulations at Extreme Scale on Leadership-Class Systems" (Bei Wang {Princeton U.}, S. Ethier, W. Tang {PPPL}, Timothy Williams {ANL}, Khaled Ibrahim {LBNL}, Kamesh Madduri {PENN}, Samuel Williams, Leonid Oliker {LBNL}) and another poster, "Scibox: Online Sharing of Scientific Data via the Cloud" (Jian Huang, Xuechen Zhang, Greg Eisenhauer, Karsten Schwan, Matthew Wolf {GATech}, S. Ethier {PPPL}, Scott Klasky {ORNL}).

ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):

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

Construction: Work continues on welding the lower TF support weldment splice plates (40% complete) and the reinforcement of the vacuum vessel leg feet. Installation of a new neutral beam rack continues on the 119' platform and welding of NB2 piping in the NSTX Test Cell continues. In-vessel fit-ups of the NB armor occurred this week and final installations will begin next week. In-vessel diagnostic installations are now scheduled for the first two weeks of December.

CS Upgrade: The internal OH ground wrap was wound on to the TF Bundle using the OH winder. Minor upgrades were added to the OH winder rollers to improve the straightening of the copper off the reel. Qualification testing of the OH Braze samples continued this week. All except one of the cyclic tests were performed and the final tensile test specimens were delivered to an outside testing laboratory for testing on November 18. During the weekly teleconference with Everson a minor error in the insulation scheme was discovered for the PF1B. Changes were made to correct the error before winding will begin. The FDR for the PF, TF, OH and CHI busswork was successfully held. Fabrication of the busywork and supports continued in the Tech Shop.

NBI Upgrade: BL2 OMA installations have been put on hold pending further review. Progress on services includes DI water manifold and valve installations, vacuum component purchases, and pneumatics installation procedure development. Armor tile and quadrant fit-up, assembly, and adjustments took place; six additional tiles needed to complete the fourth quadrant have been machined and will be sent out for bakeout. Work continues on subcontract cable tray and conduit ground installations. NB and TVPS duct component assembly has started in the NB shop.

BUSINESS OPERATIONS (K. FISCHER):

PPPL submitted two proposals in response to the Office of Science Early Career Research Program solicitation. B. Grierson submitted "Exploration of Main-ion Properties at the Boundary of Fusion Reactors." The total budget request for the five-year period of performance was $2.59 million. L. Delgado-Aparicio submitted "Impurity Induced Instabilities and their Impact on High-performance Fusion Plasmas." The total budget request for the five-year period of performance was $2.64 million.

OFFICE OF COMMUNICATIONS: (K. MACPHERSON):

K. MacPherson hosted Jorge Cham, the creator of PhD Comics, on a tour of PPPL on November 22. Cham is preparing a video/animation of fusion and plasma physics and both videotaped and interviewed several researchers. He met with A. Cohen, S. Gerhardt, S. Prager, M. Zarnstorff, H. Neilson, K. Tresemer, the PPPL graduate students (for a meet and greet), A. Zwicker, and A. Dominguez.

OFFICE OF ACADEMIC AFFAIRS (N. FISCH):

On November 18-19, N. Fisch attended the Board of Physics and Astronomy Fall Meeting in Irvine, California.

DIRECTOR'S OFFICE (C. AUSTIN):

On November 19, M. Zarnstorff held the monthly PPPL Research Meeting in the MBG Auditorium. Presentations included: a research summary by M. Zarnstorff, a Max-Planck/Princeton Center: Gyrokinetic Work and Overall Workshop summary by G. Hammett, a Lithium workshop summary by D. Mansfield, and a ST Workshop summary - by M. Ono.

On November 20, Professor Edward Felten from Princeton University presented a colloquium entitled, "Cybersnooping: Collection and Analysis of Metadata and Content".

As part of the Princeton Deconstructed Series sponsored by Princeton University training and development, A. Cohen presented a session about PPPL on November 21 in the Frist campus center.

A. Cohen attended a Sustainability Steering Council meeting on main campus on November 22.

AWARDS:

Tang, W. "High Performance Computing (HPC) Innovation Excellence Award"

Ethier, S. "High Performance Computing (HPC) Innovation Excellence Award"

COLLOQIA:

Fisch, N., "Aspects of Alpha Channeling," Tri Alpha Energy

INVITED TALKS:

Kolemen, E. "Neoclassical tearing mode control and stabilization in steady state burning plasma," MHD Workshop in Santa Fe, New Mexico.

Tang, W., "Challenges & Opportunities in Fusion Energy," 4th International Workshop on Big Data Analytics: Challenges and Opportunities (BDAC-13)

PUBLICATIONS:

Kramer, G.; *et al.*, "Simulation of localized fast-ion heat loads in test blanket module simulation experiments on DIII-D," Nuclear Fusion 53 123018.

Hay, M.J.; Valeo, E.J.; and Fisch, N.J., "Geometrical Optics of Dense Aerosols: Forming Dense Plasma Slabs," Physical Review Letters.

LEADERSHIP POSITIONS:

Tang, W., chaired meeting on the G8 "Interdisciplinary Program on Application Software toward Exascale Computing for Global Scale Issues."

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