PRINCETON PLASMA PHYSICS LABORATORY
WEEKLY highlights

PPPL
U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending November 6, 2015 are as follows:

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

Steady State Electric Network (SSEN):

Award of a subcontract for the Reactive Power Compensators procurement is still pending resolution of issues. A version was developed that responded to DOE comments and was accepted by DOE, however it was not accepted by the proposed contract awardee. Another version is in development.

As-built drawings of various components delivered to the ITER site are now being uploaded into the ITER "System for the Management of Diagrams and Drawings" (SMDD).

Diagnostics:

Upper Port Wide Angle View Visible-IR Camera (UPP WAVs): The UWAVS team held a peer review of the first mirror cleaning test chamber. TNO is building the test chamber, which is expected to be commissioned by October 2016. In addition, UWAVs met with F4E this week to discuss the integration of the diagnostic into the EU-DA's UPP.

Motional Stark Effect (MSE): Fusion For Energy (F4E), which is the European Domestic Agency (EUDA), has hired a Spanish engineering firm IDOM to handle all F4E port integration and port plug design tasks. IDOM visited PPPL this week to discuss two important topics; the first was the integration of the USDA MSE Core View system in to Equatorial Port 1, and the second was the integration of one of the USDA Upper Port Wide Angle View VIS-IR camera systems in to Upper Port 17. IDOM presented the EUDA perspective on Diagnostic Shield Module design as well as their method for handling the complex integration coordination. This was IDOM's second visit to PPPL as the two teams work to find ways to coordinate common tasks and synchronize schedules.

Core Imaging X-Ray Spectrometer (CIXS): The department met with representatives from Indiana University's Neutron Radiation Effects Facility (NREF) to start planning on nuclear testing that PPPL plan to conduct at the NREF facility early next year. The aim of the testing is to determine how well current detectors are able to withstand large levels of neutron radiation. Also, a meeting was held on site at PPPL to start efforts to prepare for a magnetic field test that will be conducted in order to determine how current generation x-ray detectors are able to withstand high magnetic fields. Both of these tests will allow PPPL to see the capabilities of current hardware and where improvements must be made.

NSTX (M. ONO):

NSTX-U is in the commissioning phase for the FY16 campaign.

The joint International Spherical Torus Workshop (ISTW-2015) and 2015 US-Japan Workshop on ST Plasmas were held at Princeton University, November 3-6. The workshop was well attended with approximately 100 registered participants. The workshop had approximately 50% international participation with representatives from China, Japan, Korea, Italy, the United Kingdom, the International Atomic Energy Agency (IAEA) in Vienna, Austria, and the United States. The workshop covered topics including compact toroids (field-reverse configurations, spheromaks) and spherical torus/tokamak physics including plasma initiation, energetic particles, core and edge transport, macroscopic stability, and wave heating and current drive. Presentations included 10 overview orals, 28 contributed orals, and 40 posters given in two poster sessions. The program also included guided tours of PPPL experimental facilities including visits to MRX, PFRC-2, LTX, QUASAR, the Hall Thruster, and the NSTX-U control room and test cell. Presentations from the workshop are archived at the following URL: http://istw-2015.pppl.gov/agenda-presentations.

The paper "Modifications to ideal stability by kinetic effects in NSTX" by J.W. Berkery (Columbia University) et al., Nuclear Fusion 55 (2015) 123007 was recently published. The paper extensively examines the ideal and kinetic resistive wall mode (RWM) stability of NSTX high beta plasmas, including variations in plasma internal inductance, pressure peaking factor, and aspect ratio. The ideal stability of nearly 5,000 equilibria was examined from 350 plasma discharges. Further kinetic RWM marginal stability calculations as computed by the MISK code continue to show the correlation of this limit with the occurrence of disruptions in NSTX. This paper represents the most comprehensive set of such stability calculations for NSTX, and further supports the use of the kinetic RWM stability model to determine proximity to disruptions.

A letter entitled "Distinct turbulence sources and confinement features in the spherical tokamak plasma regime" by W. X. Wang (PPPL) et al., has been published online in Nuclear Fusion 55 (2015) 122001 (http://stacks.iop.org/0029-5515/55/122001). The nonlinear gyrokinetic study presented in this paper has discovered two new, important turbulence sources in the ST regime, which are the drift wave Kelvin-Helmholtz (KH) instability and the dissipative trapped electron mode (DTEM). For the first time, the KH mode is identified as a driver of significant transport in realistic fusion experiments. Also for the first time, long wavelength, quasi-coherent dissipative trapped electron modes are found to be excited over a wide range of NSTX parameter regime despite the presence of strong EXB shear, providing a robust turbulence source dominant over the traditional collisionless trapped electron modes in ST plasmas. Furthermore, DTEM-driven transport in NSTX parametric regime is shown to increase with electron collision frequency, offering one possible source for the confinement scaling observed in experiments. More interestingly, the existence of a minimum plasma transport regime that future advanced STs may access is predicted.

M. Ono (PPPL) attended the International Toki Conference in Toki, Japan, November 3 – 6. He gave an invited plenary presentation entitled "Spherical Tokamaks and Fusion Energy Development Path," an overview of the world-wide ST research since 2000.

M. Ono visited the National Institute for Fusion Science (Gifu, Japan) on November 2 to discuss various collaboration topics with the NIFS and LHD scientists. He met with the LHD team members including Drs. Mutoh, Tamura, Kasahara, Seki, and Nagayama to discuss the recent ICRF results. Ono then met with Dr. Byron Peterson and his colleagues for collaboration on NSTX-U on a tangential divertor imaging bolometer system. A prototype system is being installed on NSTX-U. Ono also met with Professor Hirooka to discuss the liquid lithium and metal R&D activities at NIFS.

Vacuum leak checking for small air leaks that developed during the cool-down after the vessel bake continues. The vacuum and mass flow controls for the new deuterated trimethylboron (dTMB) system have been installed, and pre-operational testing of the dTMB system is making good progress. Power testing (into a resistive load) of the Switching Power Amplifier (SPA) systems that will be used to power the Resistive Wall Mode (RWM) coils was completed this past week. The Field Coil Power Conversion (FCPC) fault detector settings are now being finalized in preparation for field coil power testing, and the TF power supply cabling has been configured for 6 parallel power supply operation. Pre-operational testing of the Digital Coil Protection System (DCPS) was successfully completed this past week.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

Final hardware for completing the edge main-ion CER system on DIII-D has arrived on-site at DIII-D and will be installed for the next experimental campaign in December. This will complete the entire 16 channel edge main ion system and allow for full physics capability at the start of FY16 operations. Fiber optic couplers that enable consolidation of existing sightlines onto fewer spectrometers have expanded the system capability with minimal changes to the spectrometer and CCD camera configuration. The completed edge system will consist of sixteen edge toroidal sightlines covering the plasma edge form the top of the pedestal into the scrape-off layer; doubling the current capability of eight sightlines. Direct measurements of the main-ion velocity near the plasma boundary have already displayed significant differences from the impurity flows on DIII-D and are the subject of ongoing analysis and comparison with neoclassical theory.

R. Ellis and J. Hosea visited DIII-D. Upgraded motors were installed successfully on the toroidal drives of the ECH launchers. Hosea gave a talk on the scrape-off layer losses during NSTX HHFW and DIII-D fast wave operations, as well as the implications for the helicon antenna.

R. Hawryluk visited DIII-D and talked with the PPPL staff and DIII-D management about the collaboration. The preparations for the APS-DPP papers are well underway.

C-Mod (S. Scott):

R. Mumgaard visited ASDEX Upgrade at the Max Planck Society Institute for Plasma Physics last week to integrate a one-spatial-channel MSE background polychromator into the ASDEX MSE diagnostic. This system is nearly identical to the multi-spectral line-polarization MSE (MSE-MSLP) system recently deployed in collaboration with PPPL on C-Mod. The work at ASDEX Upgrade will be reported in detail in a future C-Mod highlight. S. Scott has successfully

processed one dedicated ASDEX shot using the upgraded software. This represents the first time that the new software, which was recently rewritten to be device independent, was exercised on data from a tokamak other than C-Mod. Comparisons with between the MIT/PPPL developed software and the IPP-developed software were qualitatively consistent.

THEORY (A. BHATTACHARJEE):

On November 3, N. Fisch gave the opening plenary talk at the International Toki Conference (ITC-25): Creating the Future -- Innovative Science of Plasma and Fusion. The title of the talk was "Pushing Particles with Waves: Current Drive and Alpha Channeling."

An article by I. E. Ochs, N. Bertelli and N. J. Fisch entitled "Alpha Channeling with High-field Launch of Lower Hybrid Waves" appeared online on November 4 in Physics of Plasmas 22, 112103 (2015) http://scitation.aip.org/content/aip/journal/pop/22/10/10.1063/1.4933018. This article shows how rays launched from the high-field-side of a tokamak can undergo amplification in an alpha particle gradient even as current drive by lower hybrid waves is achieved. By tracing rays in a tokamak, the required radial gradients to achieve amplification are calculated for a temperature and density regime consistent with a hot-ion-mode fusion reactor. These simulations, while valid only in the linear regime of wave amplification, nonetheless illustrate the possibilities for wave amplification using high-field launch of the lower hybrid wave. The first author is I. Ochs, a graduate student in the Program in Plasma Physics.

PLASMA SCIENCE AND TECHNOLOGY (P. EFTHIMION):

This week's Plasma Science and Technology Department seminar was presented by Vladimir Sokolov from Plasma Research Laboratory, Columbia University. His talk was entitled "Experimental Study of the ITG and ETG Modes in the Columbia Linear Machine," and the abstract reads: "The anomalous radial thermal transport generated by drift wave turbulence is a fundamental open physics question in magnetic confinement systems. A series of basic transport physics experiments on the anomalous ion thermal conduction due to the ion temperature gradient (ITG) modes had been performed in the Columbia Linear Machine (CLM). The transport isotopic mass scaling was inversely proportional to square root of ion mass. This scaling results primarily from the ion acoustic (IA) damping through 3-wave coupling of two ITG radial harmonics and an IA wave. A basic physics experimental study of zonal flows (ZF) associated with the ITG drift modes had been performed in the CLM. The ZF were detected by a novel diagnostic using the frequency modulation (FM) paradigm similar to that in radio transmission. We found power spectrum peaks at the ITG ('carrier') frequency of ~120 kHz and the FM sidebands peak at a frequency of ~2 kHz. We had definitively identified the ZF structures in cylindrical plasma that are azimuthally (poloidally) and axially (toroidally) symmetric and radially inhomogeneous. The experimental results and theoretical arguments indicated that the novel saturation mechanism of the ETG modes is suspected to be related to coupling via damped IA mode. The experimental bi-coherence data show coupling between two high frequency radial harmonics of ETG (~2MHz) and one low -frequency IA (~45kHz) modes. This coupling had been verified using novel feedback diagnostic."

OFFICE OF ACADEMIC AFFAIRS (N. FISCH):

On November 2, N. Fisch gave a colloquium entitled "Compressing light in plasma" at the Institute of Laser Engineering, Osaka University, Osaka, Japan. On November 5, Fisch gave a talk entitled "Aspects of Raman Compression," at The Graduate School for the Creation of New Photonics Industries, Hamamatsu University, Hamamatsu, Japan.

DIRECTOR'S OFFICE (C. AUSTIN):

On November 6, Professor Robert Goldston, Princeton University, presented a colloquium entitled "Technical Aspects of the Iran Nuclear Agreement."

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