The PPPL Highlights for the week ending February 3, 2017 are as follows:

**U.S. ITER FABRICATION (H. NEILSON):**

**ITER Diagnostics (R. Feder):**

Upper Port Plugs 11 & 14: UP14 port integration team had a meeting with DMS team and the IO. The DMS team has been evaluating the best possible design option for their system in UP14. Each design option creates clashes with VisIR system at different magnitudes. Weekly meetings are planned with DMS team before they pick one design option and file PCR; 2nd report from IO is received on Post First Plasma (PFP) Interface Sheet. Most of the Diagnostic design falls under this PFP phase. Each diagnostic system is evaluating this report to identify ANYS issues that may impact their system.

**NSTX-U RECOVERY PROJECT (R. HAWRYLUK):**

The third Design Validation and Verification Review (DVVR), reviewing the NSTX-U High Harmonic Fast Wave (HHFW) and Neutral Beam (NB) plasma heating systems, was held this week. The Review Committee for the Heating Systems DVVR was comprised of PPPL personnel and eight external personnel, Richard Callis (GA), Larry Grisham (PPPL-ret.), Elizabeth Surrey (UKAEA), and Randy Wilson (PPPL-ret.) attended the review at PPPL while Richard Goulding (ORNL), Jim Irby (MIT), Ronald Parker (MIT-ret.), Tim Scoville (GA), Thomas Todd (UKAEA-ret), and Stephen Wukitch (MIT) attended the review remotely. Nevell Greenough, B. Ellis, and T. Stevenson presented the material for this review and V. Riccardo chaired the review. Many good comments and suggestions (chits) were recorded, and are now being categorized into action items.

Progress continues on the development of NSTX-U System Design Descriptions (SDD’s), and drafts are being reviewed and updated. Regarding test cell work, the PF1B upper and lower coils have been removed from the machine and inspected. The upper and lower ceramic break/PF1C coil assemblies were previously removed from the machine, and engineering planning for removal of the coils is in progress.

Recommissioning of the coil winding facility continued with the assembly of the tensioning skid and the reconfiguration of the clean room and the coil oven as needed to support PF1A winding.

Also this week, progress was made on installation of FIReTIPS waveguides and SPRED diagnostic electrical systems.
**NSTX-U RESEARCH (J. MENARD):**

R. Maingi served on the Fusion Energy Sciences Advisory Committee in Gaithersburg, Maryland on February 1 -2. There was substantial discussion of a new charge given to FESAC, which relates to transformative technology, engineering and science that will advance our field toward fusion energy.

R. Kaita visited Belmont University in Nashville, Tennessee on February 1. The university recently established a College of Sciences and Mathematics with new facilities for student research. Discussions were held with faculty in physics, chemistry, and mathematics on topics that included lithium research on NSTX-U, laser-based diagnostics, and fabrication of nanomaterials.

N. Bertelli, M. Ono, and G. Taylor traveled to QUEST (Kyushu University) to attend a workshop on QUEST and related ST RF Startup and Sustainment Plasma Research. Bertelli gave a presentation entitled "PPPL code capabilities for ECH and EBW". Ono gave a presentation entitled "An overview and motivation for the NSTX-U start-up research program". Taylor gave a presentation entitled "Non-Inductive Plasma Current Start-Up, Ramp-up and Sustainment in NSTX-U". During the visit they toured the QUEST Laboratory and discussed future collaborations on QUEST experiments and modeling.

Ono visited Naka Fusion Institute in Naka, Japan on January 30. He toured the JT-60SA construction site and met with Naka Fusion Institute researchers including Drs. K. Shinohara and S. Ide. M. Ono also gave a seminar on NSTX-U initial operations and plans.

C. Myers traveled to the Culham Centre for Fusion Energy (CCFE) for the week of January 23 to collaborate with members of the JET Physics and Technology for ITER (PTI) Task Force on the topic of non-axisymmetric currents during disruptions. JET plasma current asymmetry data was collected from both carbon wall (JET-C) and ITER-like wall (JET-ILW) operations to support an ongoing ITPA activity to determine a scaling for the toroidal rotation of non-axisymmetric halo currents that can be extrapolated to ITER. The latest results from this work, which now include JET-C data, were presented at a JET Task Force meeting on January 26.

S. Kaye was named by IOP as one of their Outstanding Reviewer Award winners for 2016, in recognition of the high quality and timeliness of his publication peer reviews for Plasma.

**ITER & TOKAMAKS (R. NAZIKIAN):**

**EAST:**

R. Maingi presented a talk to OFES titled "Update on the US-China PMI collaboration in Germantown, MD". Present were D. Clark, M. Foster, J. King, M. Lancot, J. Mandrekas, J. VanDam and M. Zarnstorff. The talk focused on highlights of the collaborative experiments on lithium injection conducted on EAST in December 2016. Seven US participants visited EAST to co-lead these experiments.
**DIII-D:**

Shaun Haskey has been working with Richard Groebner, Bob Johnson, and David Kaplan at DIII-D to add an additional eight edge chords to the existing chords that have realtime CER analysis capability. This provides toroidal rotation, temperature, and brightness measurements for realtime kinetic EFIT and control applications. Routines have been updated to ensure that the spectral fitting code (CERREAL) has the correct instrumental response and between shot fiducials for the new chords. The realtime algorithm has been tested using data from old shots with results showing that the output from the realtime routines is comparable to the between shot analysis. The next step is to ensure that the data from these edge chords is available in the PCS in realtime.

An upcoming paper by A. Ashourvan, B. Grierson, T. Stoltzfus-Dueck, D. Battaglia and S. Haskey is testing the main-ion intrinsic rotation model by Stoltzfus-Dueck based on the interaction of neoclassical orbits with spatially inhomogeneous background turbulence. As part of the model validation, main-ion rotation measurements are compared to impurity measurements near the top of the H-mode pedestal. While previous investigations of deep core main-ion and impurity toroidal and poloidal rotation have shown discrepancy with the expectations from neoclassical theory, farther out in radius where the ion collisionality increases the measured main-ion rotation is closer to neoclassical calculations. The model is agreeing well with the observed scaling of intrinsic rotation with the plasma ion beta for a range of conditions including ion and electron heating and both signs of the plasma current. These results will be presented at the PPPL Research Meeting in February.

N. Logan has worked with L. Cui to optimize the DIII-D 3D field coil currents for ELM suppression and NTV optimization using the Generalized Perturbed Equilibrium Code (GPEC) within the One Modeling Framework for Integrated Tasks (OMFIT). The optimization requires post processing of the perturbed equilibrium data to predict the optimal fields for physics targets of interest. Nikolas Logan has focused on eigen decompositions of matrix representations of the toroidal torque from non-ambipolar transport which are the subject of an accepted Physics of Plasmas publication by J.K. Park and Logan. In parallel, post-processing optimization of the resonant coupling has been developed in preparation for control room optimization of the 3D coil currents that Cui will perform during an intrinsic rotation experiment next week. These physics-based optimizations are now publically available through OMFIT, and next week’s control room application represent a significant advance in the integration of 3D field predictive modeling and experimental validation.

**ADVANCED PROJECTS (H. NEILSON):**

**Stellarators (D. Gates):**

Novimir Pablant, Luis Delgado-Apraricio and James Kring (Auburn University) traveled to MIT to work with John Rice (MIT) to develop a method of performing an in-situ absolute wavelength calibration for XICS diagnostic systems. An absolute wavelength calibration is needed to improve the accuracy of poloidal flow measurements in W7-X, to provide improved calibrations for systems on EAST, K-STAR and NSTX, and is critical for the future XICS system being
developed for ITER. An experimental x-ray apparatus utilizing the HiREX-Sr spectrometer was setup to test various potential calibrations techniques. After approval of the x-ray shielding configuration by the MIT safety team, initial x-ray measurements were taken. This research activity will continue over the next two weeks.

As part of the Laboratory's collaboration with the Wendelstein 7-X (W7-X) stellarator program at Germany’s Max Planck Institute for Plasma Physics (IPP), a joint project is under way with the aim of significantly improving remote collaboration capabilities for U.S. participants. A commercial virtual private network (VPN) solution adopted by IPP last Fall allows remote access into the W7-X computer network, but initially many resources were inaccessible. Sustained efforts by IPP colleagues over the past few months, and testing by PPPL users, have significantly reduced the list of access problems. Still-open issues include access to W7-X MDS-plus resources and to shared drives at IPP; however potential solutions to these problems have been recently proposed by the team, and preparations for testing are in progress. A new development, important for U.S. collaborators, is a recent decision by the IPP directors to establish a wide-bandwidth (10 Gb/sec) link connecting the Greifswald site to the Energy Sciences Network (ESnet). This should result in much faster response and data transfer rates for U.S. users within the next few months.

THEORY (A. BHATTACHARJEE):

The recent paper titled “Action principle for Coulomb collisions in plasmas”, by Eero Hirvijoki, Physics Plasmas 23, 094502 (2016); was highlighted this week by the Physics of Plasmas as an “Editor’s Pick”. The abstract reads: “An action principle for Coulomb collisions in plasmas is proposed. Although no natural Lagrangian exists for the Landau-Fokker-Planck equation, an Eulerian variational formulation is found considering the system of partial differential equations that couple the distribution function and the Rosenbluth-MacDonald-Judd potentials. Conservation laws are derived after generalizing the energy-momentum stress tensor for second order Lagrangians and, in the case of a test-particle population in a given plasma background, the action principle is shown to correspond to the Langevin equation for individual particles.”

On February 2, Professor Alain Brizard (Department of Physics, Saint Michael's College, Colechester, USA) presented a theory seminar on recent advances in the variational formulation for reduced Vlasov-Maxwell equations. The talk presents recent advances in the variational formulation of reduced Vlasov-Maxwell equations. First, the variational formulations of guiding-center Vlasov-Maxwell theory based on Lagrange, Euler, and Euler-Poincaré variational principles are presented. Each variational principle yields a different approach to deriving guiding-center polarization and magnetization effects into the guiding-center Maxwell equations. The conservation laws of energy, momentum, and angular momentum are also derived by Noether method, where the guiding-center stress tensor is now shown to be explicitly symmetric. Next, the Eulerian variational principle for the nonlinear electromagnetic gyrokinetic Vlasov-Maxwell equations is presented in the parallel-symplectic representation, where the gyrocenter Poisson bracket contains contributions from the perturbed magnetic field.

Vasily Geyko, Graduate Student in the Program in Plasma Physics, Department of Astrophysical Sciences, Princeton University, presented his Final Public Oral Examination in the Theory Department on January 30. The title of the presentation was “Physics of Spinning Gases and Plasmas”, and his advisor: was Professor Nathaniel J. Fisch, and the committee consisted of G.
Hammett (Chair), Fisch, and I. Dodin. The abstract reads “Initially motivated by the problem of compression of spinning plasma in Z-pinch devices and related applications, the thesis explores a number of interesting smaller-scale problems related to physics of gas and plasma rotation. In particular, thermodynamics of ideal spinning gas is studied. It is found that rotation modifies the heat capacity of the gas and reduces the gas compressibility. It is also proposed that, by performing a series of measurement of external parameters of a spinning gas, one can infer the distribution of masses of gas constituents. It is also proposed how to use the rotation-dependent heat capacity for improving the thermodynamic efficiency of internal combustion engines. To that end, two possible engine embodiments are proposed and explored in detail. In addition, a transient piezothermal effect is discovered numerically and is given a theoretical explanation. The effect consists of the formation of a radial temperature gradient driven by gas heating or compression along the rotation axis. By elaborating on this idea, a theoretical explanation is proposed also for the operation of so-called vortex tubes, which so far have been lacking rigorous theory. Finally, adiabatic compression of spinning plasmas and ionized gases are considered, and the effect of the electrostatic interactions on the compressibility and heat capacity is predicted”.

Chang Liu, Graduate Student in the Program in Plasma Physics, Department of Astrophysical Sciences, Princeton University, presented his Final Public Oral Examination in the Theory Department on February 3. The title of the presentation was “Runaway Electron in Tokamaks”, and his advisors are D. Brennan, A. Bhattacharjee, and the committee consists of I. Dodin (Chair), D. Brennan, A. Bhattacharjee and G. Fu. The abstract reads: “Runaway electron generation is an interesting phenomenon in plasma physics, and play a very important role in tokamak disruption mitigation. In this thesis, we investigate several problems of wave particle interaction associated with runaway electron beams in tokamaks. Initially, we address the Cherenkov radiation of runaway electrons, which originates from the polarization of the plasma medium. The energy and momentum loss of the Cherenkov radiation can be modeled by adding a correction to the Coulomb logarithm in the collisional drag force. Subsequently, we address pitch angle scattering caused by normal modes in the plasma, which are driven unstable by the anisotropy of the runaway electron beam. The fluctuating electromagnetic fields are found to act as a seed for the unstable normal modes. Numerical simulations show that the pitch angle scattering effect from the normal modes, mainly whistler waves, can be significantly larger than that from collisional pitch angle scattering. Finally, we present a synthetic diagnostic tool we developed to calculate the electron cyclotron emission (ECE) from the runaway electrons, and successfully reproduce the prompt growth of the ECE signal observed in DIII-D quiescent runaway electron (QRE) experiments.”

DIRECTOR’S OFFICE (S. ZELICK):

On February 1, Dr. Silas Beane, University of Washington Seattle, presented a colloquium entitled, "Are You Living In A Simulation?"

On February 1-2, D. McComas, T. Brog, R. Hawryluk, M. Zarnstorff, J. Menard and H. Neilson participated in the Fusion Energy Sciences Advisory Committee (FESAC) meeting, which was held in Gaithersburg, Maryland. The committee provides independent advice to the Director of the Office of Science on complex scientific and technological issues that arise in the planning,
implementation, and management of the fusion energy sciences program. T. Brog and R. Hawryluk presented on the NSTX-U Assessment and Recovery.

On February 3, Dr. Thomas Sunn Pederson presented a colloquium entitled, "Recent results and near-term plans for Wendelstein 7-X".

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