The PPPL Highlights for the week ending September 4, 2015, are as follows:

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

M. Smith completed the benchmark of the DINA 2012 electro-magnetic (EM) analysis for the generic upper port plug. With the benchmark complete, the EM analysis of the detailed UP14 and Upper WAVS will commence.

A report documenting recent optical testing of a prototype ITER TIP retroreflector, written by R. Wood and D. Johnson, was submitted for sign off.

Seven WAV shutter blade configurations were analyzed and one configuration was selected. Preliminary thermal analyses of the intermediate optical mirrors and mounts have been completed, providing guidance for design iterations.

The DRGA team resolved the FDR-1 Cat 2a chit associated with the maintenance plan.

An alternate concept of the ECE calibration arrangement was introduced. Instead of an additional shutter/mirror, front mirrors of the optical system are rotated. This reduces the movement range of the component from 45 to 25 degrees. In addition, this eliminates discrepancies introduced during calibration by an additional mirror.

R. Feder completed an Attila finite-element neutronics heat load simulation for the UP14 and the Upper WAVs. These results are used as design input for both the port integrator of UP14 and the WAVS design team.

NSTX (M. ONO):

D. Battaglia (PPPL) presented an overview of the NSTX-U program at University of Rochester’s Laboratory for Laser Energetics on September 4. The talk gave an overview of fusion energy research using magnetic confinement, the motivation for tokamak and spherical tokamak research and summarized the scientific mission of NSTX-U. The audience included members of the community, as well people working on inertial confinement fusion research at LLE.

R. Maingi (PPPL) presented a colloquium at the Department of Physics and Astronomy, West Virginia University on September 3: "The Benefit of Coating the Plasma Facing Surfaces of Fusion Research Chambers with Low-Atomic-Number Materials in Keeping Plasma Hot, Confined, and Fusing." This lecture was sponsored by the APS Distinguished Lectures in Plasma
Physics program. WVU students, postdocs, and faculty expressed substantial interest in the worldwide use of lithium in tokamaks, and possible collaboration on PPPL lithium-related projects.

Following the successful Raman and Rayleigh scattering calibrations of the Multipulse Thompson Scattering (MPTS) diagnostic, the NSTX-U vessel underwent a brief vent to install valves for the new Argon Purge System, check interferences for LITER & MAPP, install a DTI assembly, install a window at bay J Upper, make an obstruction measurement at the Bay L port, and replace the Bay B CCD camera and shutter. The vessel is once again under high vacuum, and preparations are underway for an extended vessel bake.

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

**DIII-D (R. Nazikian):**

B. Tobias traveled to University of California - Davis to supervise testing of recently fabricated liquid crystal polymer (LCP) mm-wave heterodyning circuit modules under development for ECE-Imaging and MIR. These modules integrate state-of-the-art GaAs MMIC devices to pre-amplify and down-convert ECE and reflectometer signals on a single, compact circuit approximately 3 cm^2, replacing bulky discrete components, large quasi-optical lenses, and many meters of costly corrugated waveguide that are currently used to carry local oscillator power from sources located outside the machine hall to detector arrays near the vacuum vessel. Testing is ongoing, but initial data indicate dramatic improvement in signal-to-noise and stability over currently employed techniques.

Madeline Vornkamp, (University San Diego senior) presented her summer internship work summary this week to approximately 15 GA engineering and management staff. Her work spanned a spectrum of engineering design, fabrication, and testing interlaced with hands on mechanical and electrical work.

A. Nagy and the Helicon team successfully removed all but one of the large FMIT components to a staging area outside of the FMIT source zone. This required securing all of the equipment from any electrical connections. The heavy units were lifted onto rollers and transported to the loading ramp. This prepares the way for the high power klystrons for the Helicon system.

**International Collaborations (R. Hawryluk):**

D. Darrow and N. Gorelenkov attended the IAEA TCM on Energetic Particles in Magnetic Confinement Systems, held September 1-4 in Vienna, Austria.

R. Hawryluk chaired the Fachbeirat meeting in Greifswald reviewing the IPP program. M. Zarnstorff also attended the meeting.
ADVANCED PROJECTS (H. NEILSON):

As part of his yearlong stay during the first experimental campaign at Wendelstein 7-X (W7-X), S. Lazerson has been working with researchers to develop methods to detect and measure error fields using the vacuum flux surface mapping diagnostics. It was planned to conduct an analysis using a configuration in which the rotational transform (iota) at the magnetic axis was about 1. This should produce a helical excursion of the magnetic axis if n=1 error fields are present. A compass scan, in which an applied n=1 perturbation using the U.S. provided trim coils is systematically scanned in toroidal phase angle, would be performed. This plan was delayed, however, due to technical difficulties that precluded creating this configuration before first plasma. An alternative configuration which places an iota=0.5 surface in the vacuum configuration and is realizable within current technical constraints was proposed by Lazerson, whose analysis has shown that an m=2 island will form if error fields are present. Lazerson's proposed experiment has been favorably received by the W7-X team and will be carried out in the coming weeks. This will mark the first U.S.-proposed experiment on W7-X. In addition, Lazerson and other U.S. collaborators met with the DOE Fusion Energy Sciences Director Ed Synakowski to discuss the realities of foreign collaboration on W7-X, during Synakowski's recent visit to Greifswald, Germany.

THEORY (A. BHATTACHARJEE):

E.-H. Kim gave an invited talk entitled "Full-Wave Modeling of EMIC Waves in the Earth’s magnetosphere" for the East-Asia School and Workshop on Laboratory, Space, and Astrophysical plasmas on August 20. The abstract reads: "Electromagnetic (EMIC) waves are known to be excited by the cyclotron instability associated with hot and anisotropic ion distributions in the equatorial region of the magnetosphere. One of the significant scientific issues concerning EMIC waves is to understand how these waves are detected at the ground. In order to solve this puzzle, it should be investigate propagation characteristics of the field-aligned EMIC waves, which include polarization reversal, cutoff, resonance, and mode coupling between different wave modes, in dipolar magnetic field. However, the inability of ray-tracing to adequately describe wave propagation near the crossover cutoff-resonance frequencies in multi-ion plasma is a one of reasons why the scientific questions remain unsolved. Using recently developed 2D full-wave code that solves the full wave equations in global magnetospheric geometry, we demonstrate how EMIC waves propagate to the higher magnetic latitude in electron-proton-He+ plasma. We found the polarization reversal occurs at the crossover frequency from left-hand (LH) to right-hand (RH) polarization and such RH EMIC waves can either propagate to the inner magnetosphere or reflect to the outer magnetosphere at the Buchsbaum resonance location. We also found that mode-coupling from guided LH EMIC waves to unguided RH or LH waves (i.e., fast mode) occurs at the crossover location, which is consistent with previous 1D full-wave analysis."

D. E. Ruiz and I. Y. Dodin published a paper titled "On the correspondence between quantum and classical variational principles" [Phys. Lett. A 379, 2623 (2015)]. The paper shows how classical variational principles can be deduced from quantum variational principles via formal reparameterization of the latter. It is shown that such reparameterization is possible without invoking any assumptions other than classicality and without appealing to dynamical equations. As examples, first principle variational formulations of classical point-particle and cold-fluid...
motion are derived from their quantum counterparts for Schrödinger, Pauli, and Klein-Gordon particles.

A. Hakim gave Research and Review Seminar, entitled "High-order energy conserving, (discontinuous) finite-element algorithms for (gyro) kinetic simulations of plasmas". The abstracts reads: "Gkeyll aims to be a production quality code for the simulation of plasma edge turbulence with the gyrokinetic model. In this review, I will report on progress towards this goal, and also report on efforts to implement full kinetics (Vlasov-Maxwell system). A general class of high-order continuous/discontinuous Galerkin algorithms, based on discretizing the Poisson Bracket operator, have been implemented. A careful choice of basis function for representing the Hamiltonian and the distribution function yields a spatial scheme that conserves the quadratic invariants of the system. Combined with a finite-element solver for the potentials then yields a scheme which conserves the total energy (particles + fields) exactly. Momentum conservation, though not exact, is independent of velocity space resolution, and converges very rapidly with increasing spatial resolution. Self-adjoint smoothing operators have been developed to efficiently handle magnetic fluctuations. For the Vlasov-Maxwell equations, an alternate scheme is implemented. This discretizes the E and B fields directly (rather than the electromagnetic potentials), and, with a proper choice of numerical fluxes, also yields an energy-conserving scheme. In addition, I will very briefly list the various projects, which are at present being studied with Gkeyll. These include, gyrokinetic turbulence, sheath physics in Hall thrusters (recently funded via an AFOSR grant), reconnection physics with multi-moment fluid models, fluid studies of a conceptual design of a novel divertor heat-exchanger concept, solar wind turbulence, and multi-moment fluid global simulations of the magnetosphere."

Derek Schaeffer - UCLA gave a Theory Seminar entitled "Generation of Magnetized Collisionless Shocks in the Laboratory": Collisionless shocks, in which dissipation is provided by electromagnetic rather than collisional effects, are ubiquitous in many space and astrophysical plasmas. However, since these shocks are largely steady-state, in situ measurements by spacecraft have focused on properties of pre-formed shocks. Recent experiments at UCLA have successfully generated magnetized collisionless shocks, allowing new studies of shock formation relevant to space shocks. These experiments combined a preformed, magnetized background plasma from the Large Plasma Device with a magnetic piston driven by the high-energy Raptor laser incident on a plastic target. Magnetic flux measurements and 2D hybrid simulations indicate that a magnetosonic pulse consistent with a low-Mach number collisionless shock was formed in the ambient plasma. The characteristics of the shock are compared to previous experiments in which no shock formed, and the results suggest that the various experimental conditions can be organized into distinct regimes by coupling strength. With additional experiments on the early-time parameters of the laser plasma utilizing Thomson scattering, spectroscopy, and fast-gate filtered imaging, these regimes are found to be in good agreement with theoretical shock formation criteria.

Zhiwei Ma - Zhejiang University presented Theory Seminar, Influence of toroidal rotation on resistive tearing modes in tokamaks: Influence of toroidal equilibrium plasma rotation on m/n=2/1 resistive tearing modes is studied numerically using a 3D toroidal MHD code (CLT). It is found that the toroidal rotation with or without shear can suppress the tearing instability and the Coriolis effect in the toroidal geometry plays a dominant role on the rotation induced stabilization. For a high viscosity plasma (τR/τV>>1, where τR and τV represent resistive and viscous diffusion time, respectively), the effect of the rotation shear combined with the viscosity
appears to be stabilizing. For a low viscosity plasmas ($\tau_R/\tau_V<<1$), the rotation shear shows a destabilizing effect when the rotation is large.

PLASMA SCIENCE AND TECHNOLOGY (P. EFTHIMION):

The workshop on negative ion sources for fusion and accelerator research at PPPL was organized by I. Kaganovich. The agenda included the following talks: L. Grisham, "Introduction to workshop and history of negative ion sources for fusion"; Marthe Bacal "Review of negative ion sources for fusion and accelerator research"; Francesco Taccogna "Modeling of negative ion sources for fusion and accelerator research", I. Kaganovich "Self-organization of plasmas with negative ions and ball lightning", Y. Raitses "Anomalous electron transport in ExB discharges", J. Carlsson "Simulation of anomalous electron transport in ExB discharges", Yuantao Zhang, "Microplasmas with negative ions".

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