



**The PPPL Highlights for the week ending May 16, 2014, are as follows:**

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

After many iterations of drafts, the negotiations on the technical annexes for the Procurement Arrangements for the Core Imaging X-ray Spectrometer and the Motional Stark Effect Diagnostic are nearing completion.

At a monthly progress meeting with the IO Diagnostics Division, an example of port integration was presented to illustrate the complexity of meeting all of the various engineering requirements for the port plugs, while adhering to the weight limit. A request was made to seek relief in the weight limit to permit simpler solutions.

### **ITER & TOKAMAKS (R. HAWRYLUK):**

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

R. Maingi participated in a dedicated experiment to assess the effect of lithium injections on recycling and H-mode pedestal properties. The lithium delivery was enabled by an aerosol injector on loan from NSTX-U and the device was developed by D. Mansfield, who also participated in the experiment on-site. Lithium delivery rate and timing scans were accomplished. With an appropriate amount of lithium dropped into the plasma, ELM frequency was reduced and ELM-free H-modes were observed of several hundred msec duration. The density and temperature profiles broadened substantially, similar to profile changes seen with lithium evaporation in NSTX.

R. Nazikian served as session leader for a joint experiment between the 3D task force and the pedestal physics groups aimed at understanding the plasma response to Resonant Magnetic Perturbations in ELM suppressed plasmas. Extensive data was collected with magnetic probes and imaging diagnostics under a range of plasma conditions in and out of the ELM suppression window. The data will be used to compare to plasma response predictions from several codes such as IPEC, VMEC and M3D-C1.

A. Reiman visited DIII-D to participate in experiments aimed at assessing the 3D magnetic response of the plasma to applied  $n=3$  Resonant Magnetic Perturbations. The experiment focused on double null plasmas where ideal MHD predictions using VMEC could be compared to linear ideal MHD (IPEC) and linear two fluid (M3D-C1) predictions for the plasma response.

R. Budny visited GA this week to collaborate with the DIII-D team on his analysis of high beta poloidal DIII-D/EAST demonstration discharges.

The Pole Shield Design team met to discuss the latest radiative thermal analysis results. It was found that the thermal radiation from the opposite facing pole shield added negligible heat load compared to the beam heat load on each plate. A remaining detail for analysis is the copper strain relief on the edge of the Mo plate. A follow up meeting is planned for next Wednesday to address this final issue in the analysis. A design review is planned for the end of May.

### **C-Mod (R. Hawryluk):**

There was a conference call on May 13 to discuss the progress of GBS code modeling of C-Mod edge turbulence, and to plan the MP to further test this model. The Lausanne group (Federico Halpern and Paolo Ricci) described their latest GPS simulations of limited circular discharges based on previous runs at  $B=2.7$  and  $3.8$  T. The discussion among Jim Terry and Brian LaBombard of C-Mod and M. Podesta and S. Zweben of PPPL concluded with a plan to run the new shots for the MP at near  $4.0$  T with a density and  $q(a)$  scan, along with improved edge plasma and turbulence diagnostics.

R. Perkins is at C-Mod this week participating in ICRF experiments, including a comparison of the performance of different antennas. J. R. Wilson is also at C-Mod participating in lower hybrid current drive experiments.

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

A manuscript by D. Mikkelsen on benchmark calculations for the gyrokinetic codes GS2 and GKV-X is currently under review by National Institute for Fusion Science (NIFS) co-authors. The benchmarks are based on an ion-internal transport barrier plasma in LHD, and there is very close agreement in the two independent calculations of the geometric coefficients in the gyrokinetic equation. The linear stability results for ion temperature gradient (ITG) modes (with adiabatic electrons) agree very closely for lower poloidal wavenumbers and agree to better than 10% at the peak growth rate, but growth rates differ significantly for higher wavenumbers. Eigenfunction shapes agree well, with only localized differences, for all wave numbers.

An article by S. Lazerson, "The ITER three-dimensional magnetic diagnostic response to applied  $n = 3$  and  $n = 4$  resonant magnetic perturbations," has been accepted for publication in the journal *Plasma Physics and Controlled Fusion*. The paper reports calculations of ITER magnetic diagnostic response to applied  $n=3$  and  $n=4$  resonant magnetic perturbations. Forward modeling of the ITER magnetic diagnostics indicates significant non-axisymmetric plasma response, exceeding 10% the axisymmetric signal in many of the flux loops. Magnetic field probes seem to indicate a greater robustness to 3D effects but still indicate large sensitivities to 3D effects in a number of sensors. Forward modeling of the diagnostics response to 3D equilibria allows assessment of diagnostics design and control scenarios.

In the Laboratory's collaboration with Germany's Wendelstein 7-X stellarator program, a project execution plan for the x-ray imaging crystal spectrometer diagnostic was issued. The plan

documents the deliverables, budget, schedule, and division of responsibilities among the parties.

### **THEORY (A. BHATTACHARJEE):**

A paper entitled "Geometric view on noneikonal waves", by I. Y. Dodin, was published in Physics Letters A [PLA 378, 1598 (2014)]. In this paper, an axiomatic theory of classical nondissipative waves is proposed that is constructed based on the definition of a wave as a multidimensional oscillator. Waves are represented as abstract vectors in the appropriately defined space with a Hermitian metric. The metric is usually positive-definite but can be more general in the presence of negative-energy waves (which are typically unstable and must not be confused with negative-frequency waves). The very form of wave equations is derived from properties of the vector space. The generic wave equation is shown to be a quantum like Schrödinger equation; hence one-to-one correspondence with the mathematical framework of quantum mechanics is established, and the quantum-mechanical machinery becomes applicable to classical waves "as is". The classical wave action is defined as the density operator. The coordinate and momentum spaces, not necessarily Euclidean, need not be postulated but rather emerge when applicable. Various kinetic equations flow as projections of the von Neumann equation for the density matrix. The previously known action conservation theorems for noneikonal waves and the conventional Wigner-Weyl-Moyal formalism are generalized and subsumed under a unifying invariant theory. Whitham's equations are recovered as the corresponding fluid limit in the geometrical-optics approximation. The Liouville equation is also yielded as a special case, yet in a somewhat different limit; thus ray tracing, and especially nonlinear ray tracing, is found to be more subtle than commonly assumed. Applications of this axiomatization are also discussed, briefly, for some characteristic equations.

### **ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):**

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

Construction: Work on MSE, sFLIP and the first RF compliant centerpost continued in-vessel this week. Procedures are being prepared to move the DNB slightly as part of the alignment process. The new centerstack ceramic breaks have been assembled and a leak check fixture is being fabricated. The work on the new RWM coils continued with welding mounting blocks to the vessel for the JK coil and the potting of the TF outer leg aluminum blocks continues. The installation of vacuum system cables continues. The bay J port cover has been prepared for installation in a few days. The MSE-CIF calibrations have been completed.

CS Upgrade: The final water fitting and locking brazes were completed and clamps released from the coil. Only ground wrap and VPI remain to complete the coil. The hollis water jet cut the OTF fingers and performed a successful prototype assembly of a sample finger in 304SS to test fixturing. The weld qualification samples were also fabricated and sent to the laboratory for specimen cutting and testing. A delivery schedule is holding for the end of June. The lower PF1A coil placed on the turning fixture in preparation for mounting and cover installation. Major Tool revisited the CMM data from the first passive plate and discovered the error was in how the plate was oriented to the holes. The greatest out of tolerance measurement was 0.004" when the edges of the plate were rotated slightly relative to the holes. Trimming of the outside of the plate

would bring three of the four edges into tolerance and leave the inside edge short by 0.020", which is acceptable. The OTF Finger support brackets were received and inspected. The second G10 crown piece is near completion at Imperial Machine and is scheduled for delivery next week.

NBI Upgrade: High Voltage transmission line installation continued in NTC; BL2A installation was completed. BL2B relocation was completed; installation is in progress and transmission line support installation continues. The VV RWM coil fabrication continues for the Bay JK area. The vacuum system roughing line fabrication and installation continues in the NTC. The SF6 line fabrication and installation in the NTC was on hold this week. The NB Armor thermocouple scanning system installation into the rack is in progress. The Mod/Reg controls work and preparation continues. NB Controls work on rack, cable, and wiring continued in NTC and gallery. Telemetry fiber optics splicing has been completed in TCB and termination preparation and polishing is in progress in NTC. Additional NB installation procedures are in development and review. Management attended the monthly IPT and EVM status meetings.

Digital Coil Protection System: A meeting was held to cover DCPS software, hardware, operations, and electrical engineering issues; most of the items were resolved allowing progress to continue. DCPS software builds included changes for MDSplus tree data, shot number synchronization, and sections for post disruption currents, as well as some other code cleanup changes related to decisions made at the meeting. DCPS PTP testing continued in FCC, including tests of the new builds. Work continued on the DCPS GUI with steady progress noted. The hardware and I/O layout and design continues and nears completion. The work on hardware drawings continues and is also nearing completion. The HW user interface panel design updates for new status and nomenclature are being incorporated. PCB design is in progress and procurements are planned. An electronics parts list was generated for purchase of off the shelf items. Water PLC testing continues; individual I/O testing is complete and documentation nears completion. The HSC testing development continues. A Lemo connector cable order is being prepared. Development of a procedure section for stage 2 pre-operational testing has started. Development of an operations procedure for controlling DCPS operations and administration has started. Review of reliability, failure modes, and administrative control using independent verification has started. Management attended the biweekly project status meeting.

### **BUSINESS OPERATIONS (K. FISCHER):**

A Work for Others proposal to support Princeton University on a grant received from the Air Force Office of Scientific Research was submitted to DOE for approval. The PPPL Principal Investigator for this effort is Y. Raitses; the funding to be provided by Princeton University is \$210,000 for the three-year period of performance.

PPPL submitted a proposal to DOE via the Portfolio Analysis and Management System (PAMS), titled "Advancing the Frontiers of Plasma Theory and Simulation." This proposal is a five-year plan (FY15 - FY19) for the Theory Department of PPPL. A. Bhattacharjee is the Principal Investigator.

## **BEST PRACTICES & OUTREACH (J. DELOOPER):**

At the request of the Chief of Readiness & Emergency Management at the McGuire Air Force Base, MINDS was deployed at the McGuire open house which was attended by > 300,000 visitors during May 9-11. MINDS effectively scanned those entering the military base during the three-day event.

A. Morrison is supporting ESH&S by drafting revisions of several ES&H Directives chapters. Morrison met with W. Slavin and C. Brunkhorst to discuss several questions and proposed changes on Section 4 - RF/Microwave/Magnetic Safety and Magnetic.

## **DIRECTOR'S OFFICE (C. AUSTIN):**

On May 14-15, the PPPL Advisory Committee meeting was held at PPPL. The Advisory Board presented their report to the PPPL Management Group Board of Directors on May 16. The Board includes Princeton University President Christopher Eisgruber.

On May 14, Professor Robert Crease of Stony Brook University and Dr. Vladimir Shiltsev of Fermi National Accelerator Laboratory presented a colloquium entitled, "Mikhail Lomonosov - Father of Russian Science".

A. Cohen hosted a delegation of executives from ExxonMobile Research and Engineering on May 14. The group of twelve participated in a presentation by Cohen and toured NSTX. T. J. Wojnar, President of ExxonMobil Research and Engineering Company and Doug Collin, Chief Attorney, were among the participants.

## **PUBLICATIONS:**

Dodin, I.Y., "Geometric view on noneikonal waves," Physics Letters A 378, 1598 (2014).

This report is also available on the following web site:

<http://www.pppl.gov/publication-type/weekly-highlights>