PRINCETON PLASMA PHYSICS LABORATORY
WEEKLY highlights

PPPL
U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending November 8, 2013, are as follows:

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

Amendments to the Request for Proposals for design and fabrication support for the ITER upper cameras and the ECE diagnostics were issued with responses to questions raised the previous week at pre-proposal meetings.

For design and fabrication support for the toroidal interferometer/polarimeter (TIP) diagnostic, a "sources sought notification" was prepared with links to a website containing a draft statement of work and numerous other applicable documents.

Cross-checking of CATIA models created at the IO and at PPPL indicated a discrepancy in the positioning of the TIP laser sight-lines, which is under investigation. This discrepancy impacts the interface sheet specifying the locations and orientations of the TIP retroreflectors.

Retired PPPL physicist D. Mansfield began work providing technical expertise in the procurement of the TIP diagnostic design and fabrication support, and in the PPPL design of the in-vessel optics for this system. A concept for mounting TIP mirrors at the front of equatorial port plug 9 was reviewed.

NSTX (M. ONO):

A paper "First observations of ELM triggering by injected lithium granules in EAST" by D. K. Mansfield (PPPL) et al. has been published in Nuclear Fusion. The paper describes the first use of small (d = 0.7 mm) Li granules to pace / trigger ELMs on the EAST tokamak. This work was completed as part of an international collaboration between PPPL and the Chinese Academy of Sciences' Institute of Plasma Physics. Follow-on experiments are planned for the 2014 EAST experimental campaign. (see publication section for references)

Preparations for plasma operations in the NSTX-U configuration continued with the completion of the installation of the new firing generators in the Field Coil Power System (FCPC) rectifiers. The re-commissioning of the rectifiers themselves continues with the implementation of the fiberoptic control/communication links for the firing generators and the new PLC-based fault controls.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

A. Nagy is leading an effort to repair a faulty I-coil on DIII-D, which was found to have a ground fault last year. Efforts to date have focused on developing a procedure for the removal of the faulty I-coil. The goal of the project is to disassemble the I-coil, identify and repair the ground fault and internal water leak and reinstall the coil during the current vent to resume operation in the next physics campaign.

A paper entitled "Non-axisymmetric magneto-hydrodynamic equilibrium in the presence of internal magnetic islands and external magnetic perturbation coils" by Ben Tobias et al., was recently accepted for publication in Plasma Physics and Controlled Fusion. Abstract: Non-axisymmetric equilibria arise in DIII-D discharges that are subjected to magnetic perturbation by 3D magnetic coils. But, 3D shaping of the entire plasma, including the boundary, also occurs in the rotating fluid frame of saturated internal magnetic islands (Tobias *et al* 2013 *Plasma Phys. Control. Fusion* 55 095006). This is advantageous since internal islands and kink responses that rotate near the fluid velocity of the plasma are easily diagnosed, while static perturbations in the laboratory frame are not. The helicity of the perturbed shape is the same in both rotational frames of reference, making one mode a diagnostic proxy for the other and allowing internal modes to be used as a source of data for comparison to models typically applied to understanding the effect of static perturbations. Discrepancies with ideal magneto-hydrodynamic equilibrium obtained by the IPEC (Park *et al* 2007 *Phys. Plasmas* 14 052110) method brings attention to the treatment of plasma displacements near rational surfaces and their relationship to the accessibility of equilibrium states.

KSTAR (R. Ellis)

R. Ellis attended the Asia Plasma and Fusion Association conference in Gyeongju, Korea, and presented a paper, "Upgrades for the KSTAR ECH Launchers." At the conference with roughly 180 registrants, delegations from India, China, Japan and Korea presented overview and detailed talks on many aspects of their fusion programs.

ADVANCED PROJECTS (H. NEILSON):

In the Laboratory's collaboration on Wendelstein 7-X (W7-X), final project documentation tasks are being completed. M. Mardenfeld has issued a set of as-built drawings for the trim coils that were fabricated by PPPL, as well as an operating manual for the coils. The latter defines the safe operating envelope for the coils, based on PPPL's analysis as documented in a structural analysis report that was issued as part of final design. These documents complete a formal "Declaration of Incorporation" document, a Max Planck Institute for Plasma Physics (IPP) requirement that documents the conformity of the PPPL-supplied coils to IPP's technical requirements.

With the W7-X trim coil project nearing completion, new tasks focused on experimental research issues are well under way. A key emphasis of the U.S. collaboration is the interface between the W7-X magnetic island divertor and the high heat-flux material surfaces. S. Lazerson has been investigating the sensitivity of the divertor target strike point to changes in coil currents, most

recently examining the effects of varying the planar coil currents. On the engineering side, PPPL is supporting ORNL in the design of the TDU scraper element. To this end, PPPL has begun work on a one-dimensional thermal simulation of the of the tile-backplate-support-vessel system in response to incident heat flux, along with some examples of analyses of internal components for NSTX and Alcator C-Mod.

THEORY (A. BHATTACHARJEE):

A new theory opens the door to using stochastic variational integrators to perform simulations of stochastic interactions such as Fermi acceleration. Before the discovery of relativity, Einstein solved another riddle of physics, the Brownian motion, in 1905. He derived a Fokker-Planck equation (FPE) for the statistical properties of the Brownian motion, and from this equation the famous Einstein relation. One year later, Langevin recovered Einstein's result from a different, "infinitely more simple" approach using a differential equation, which now bears his name and is known as the first stochastic differential equation (SDE). In essence, the remarkable achievement of Langevin was to find a SDE that is able to recover the statistical properties of the physical system described by the Fokker-Planck equation derived by Einstein. However, when trying to apply this method to inhomogeneous systems in higher dimensions, one finds that there exist many different SDEs corresponding to one given FPE. Are these different SDEs all equivalent? Is there a unique way to select the correct SDE? This question was answered by Joshua W. Burby, a graduate student at Princeton University, and his collaborators in a paper published this week in Physical Review Letters (see publications section for reference). To put this question to rest, the Einstein-Langevin theory needs to be generalized using a modern geometric method. It turns out that the two-particle FPE uniquely determines a Hamiltonian Langevin equation, and a procedure using the reproducing kernel of a Hilbert space of vector fields is developed to calculate the terms in the Langevin equation. In this geometric framework, the Hamiltonian nature of the underlying microscopic dynamics is retained for both the Fokker-Planck equation and Langevin's equation, which also opens the door to using stochastic variational integrators to simulate stochastic interactions, such as the Fermi acceleration, with long-term statistical fidelity.

Dr. Scott Boardsen (NASA/GSFC, University of Maryland) gave a talk entitled "Recent progress on ultra low frequency (ULF) waves at Mercury" for theory/helio seminar on November 7. Waves are primarily observed in two frequency ranges in Mercury's inner magnetosphere. Among them, waves in 0.2 to 2 Hz are believed to be related to either/or waves on the magnetopause that feed field-line resonances, or caused by local instabilities. In his talk, he focused on whether these waves could be due to a local instability from the large planetary loss-cones imposed upon a high proton beta plasma ~0.1 to 0.5. He showed that (1) the proton distribution is highly unstable to the ion-Bernstein mode and that the moderately high proton beta of 0.1 yields solutions with a significant wave magnetic field component; and (2) as the waves propagate, they cycle back and forth across the magnetic equator. For half of each cycle the wave mode is compressional, while in the other half it is moderate/weakly compressional.

Fatima Ebrahimi presented a talk entitled "Helicity-Driven Alpha Effect in Laboratory and Astrophysical Plasmas" at the Max Planck/Princeton Plasma Center general meeting on November 1. She presented the results from a recent paper by F. Ebrahimi and A. Bhattacharjee submitted to Phys. Rev. Lett.

COMPUTATIONAL PLASMA PHYSICS GROUP (S. JARDIN):

The M3D-C1 code is now fully operational and in production mode on the multi-petaflops Cray XC-30 system at NERSC named Edison. This installation involved considerable collaboration between J. Chen (PPPL), N. Ferraro (GA), the SCOREC team at RPI, CRAY research, the NERSC consultants and the PETSc team in order to track down compiler bugs and software incompatibilities between different releases of the many libraries used by the code. M3D-C1 is normally memory limited when running on the older NERSC Cray XE6 machine Hopper, and for most jobs uses only 12 of the 24 processors per node because of these memory limitations. Edison has twice the memory per node as Hopper, and so M3D-C1 can make use of all the processors on each node, resulting in a relative speedup of about two comparing two jobs using an equal number of nodes on the two machines.

A TRANSP Users Group meeting will be held on November 14 from 12:30 - 2:00pm in the Directors Row H room in the Sheraton at the APS meeting in Denver, Colorado. The TRANSP team will make short presentations highlighting the progress that has been made in several areas, among them: (1) parallel solver development, (2) new free-boundary equilibrium and control capabilities, (3) NUBEAM enhancements, (4) automated regression testing, (5) TRANSP at NERSC. The remainder of the meeting will be for discussion and to hear requests from TRANSP users.

ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):

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

As part of the NSTX startup process the PPPL Activity Certification Committee (ACC) met to review the digital coil protection system (DCPS). Addendums to the Safety Analysis Document (SAD) for a DCPS Failure Modes and Effect Analysis (FMEA) were suggested.

CS Upgrade: The centerstack pedestal was completed and shipped to PPPL on November 7. Delivery is expected the week of November 11. The Aquapour procedure and then the wet layup over layer were completed early in the week. The OH interface parts were fit up and installed. The TF bundle was reoriented to the horizontal position on November 8. The OH winding station completed it brake tensioning tests and a new winch was installed and operated. A minor modification is in process to give the winch a mechanical advantage to complete the final tensioning brake pad breaking run. A wet layup test article was completed and will be cut into test specimens next week to perform some simple compressive load tests. Modifications to the OH brazing station and programming were completed. Qualification of OH conductor brazing personnel was conducted throughout the week. Samples are now in the material test lab being testing using a 400k-cycle fatigue test.

Construction: Scaffolding and a temporary platform have been removed from the north side of NSTX. PF5 clamp new hardware installation continues. The lower dome gas injection piping is 90% installed and leak checked. The alignment of the lower TF support weldments continues with the fabrication/installation of shims and machining of the splice plates - welding will begin the week of November 11. The hot helium manifold is being welded back in place. The

electricians are working on ex-vessel flux loops and tray in the northwest quadrant of the NSTX test cell.

NBI Upgrade: BL2 source platform work was completed, alignments were confirmed, and the transit stand was removed from the NTC. BL2 ion source access platform was modified to allow installation of a support beam for cable tray. A small NE shift of BL2 C HVE was completed. Transmission line routing was analyzed further and a support beam was shifted by approximately one foot to improve the route. Plans and packages for the vacuum system services continue to be developed. Parts are also being made in the Tech Shop for the BL2 DI water system manifolds. Preparations for the pneumatic lines were evaluated for the development of an installation procedure. The Port Extension was installed on the Bay K port. A pre-job brief was held to start the NBI duct installation. The first step - removal of the VV leg strut - was completed. Armor thermocouple fabrication and assembly is in progress; TC installation and tile assembly is imminent. The Maul subcontract for power cable and tray continues with conduit and tray installation in TTC and NTC. Support installation is in progress. Work orders were submitted for JK RWM coil prototyping, fabrication, and installation. Management held the monthly job status meetings with active jobs reporting EVMS data and plans.

DIRECTOR'S OFFICE (C. AUSTIN):

On November 6, Dr. Noah Jafferis from Harvard University's Microrotics Laboratory, presented a colloquium entitled, "Robotic Bees: Overview, Actuation, and Power".

November 6 -7, the bi-annual PPPL Advisory Committee was held at PPPL. The purpose of the PPPL Advisory Committee is to review the efficiency and effectiveness of the Laboratory science and operations.

PUBLICATIONS:

Mansfield, D.K. (PPPL) et al., "First observations of ELM triggering by injected lithium granules in EAST, Nuclear Fusion 53 (2013) 113023, http://stacks.iop.org/0029-5515/53/113023

Burby, J.W.; Zhmoginov,A.I.; Qin, H.; "Hamiltonian Mechanics of Stochastic Acceleration," Phys. Rev. Lett. 111, 195001 (2013) http://link.aps.org/doi/10.1103/PhysRevLett.111.195001

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