PRINCETON PLASMA PHYSICS LABORATORY
WEEKLY highlights

PPPL
U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending August 2, 2013, are as follows:

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

Nuclear heating modeling of the latest TIP corner-cube retroreflector (CCR) design was completed and indicates that clever CCR design will be needed to avoid active cooling. There is strong motivation to avoid active cooling to facilitate replacement of these components by remote handling.

Mature drafts of the Statements of Work for design support for the Upper Cameras and the ECE diagnostic were completed and submitted as input to 'sources sought notifications' that will appear next week.

Discussions were held with IO diagnostic experts on the impact of the heating beam and diagnostic beam current density non-uniformity specification on the capability of the MSE system to meet the ITER measurement requirements. A memo explaining these concerns is being drafted to send to the ITER beam group to encourage them to test with sufficient sensitivity to indicate the severity of the effect.

Scope negotiations with the IO have begun as part of the preparation of the Procurement Arrangements for the ITER MSE and CIXS diagnostics.

NSTX (M. ONO):

The NSTX-U PAC-34 teleconference was held July 30. The PAC was presented a brief report on NSTX-U Program and Project progress since PAC-33. The primary goal of the teleconference was to review and provide comments on the draft Program Letter for the upcoming FES solicitation for Research Collaboration by Universities and Industry for FY 2014-2017. The PAC report is expected this week, and the program letter is expected to be available on August 9.

A NSTX-U researcher, A. Diallo (PPPL), is the recipient of the DoE early career research award from FY 14 through FY 18. His proposal's goal is controlling the edge pedestal structure to guarantee maximum core fusion performance in next step devices such as ITER and Fusion Nuclear Science Facility (FNSF). One of the objectives of this proposal is to understand the physics of the pedestal buildup and demonstrate the control the pedestal structure on National Spherical Torus Experiment-Upgrade (NSTX-U). To achieve this goal, this proposal specifically calls for the implementation, in collaboration with Plasma Science laboratory at the University of Wisconsin, of a burst laser system capable of delivering 1.5 J per pulse at 30 Hz with the added

feature of providing 10 – 12 kHz rep rate for few ms. This added feature will enable Thomson scattering measurements that will provide enhanced temporal measurement of the electrons density and temperature in the edge pedestal. Such enhancement will provide the key ingredients for the understanding of the physical mechanism at play in the evolution of the density and temperature pedestal structures. Finally, a component of his proposal will be to implement and demonstrate an open loop control of the pedestal structure to steer the plasma away from stability boundary of the plasma.

Vlad Soukhanovskii (LLNL) has travelled to General Atomics where he spent the week July 22-26 participating in divertor experiments and diagnostic activities. Discussions were held with LLNL and GA staff on the development of novel diagnostic sensors for radiative divertor feedback control and divertor Thomson scattering system. Both projects are presently ongoing at DIII-D with an aim of future implementation on NSTX-U. He served as a Session Leader and led the snowflake divertor experiment on July 23. Researchers from LLNL, GA, PPPL, UCSD and SNL assisted with experimental and diagnostic arrangements. The experiment focused on pedestal conditions, divertor heat transport and radiation distribution with the snowflake divertor configuration. An algorithm with pre-programmed F5B coil current was used to form and maintain snowflake-minus configurations with a small inter-null point separation for up to 3 s. Pedestal and divertor conditions were documented between and during Type I ELMs over a number of discharges spanning an NBI power range 1-5 MW, density range 4.5-7.5x1e19 m^-3, and two different plasma currents 0.9 and 1.2 MA. At higher densities, partial detachment of the outer strike point was observed in the snowflake configuration. At the lowest NBI power, reciprocating probes were used for the first time to collect data in the separatrix region. E. Kolemen (PPPL) led the implementation and testing of a snowflake configuration magnetic feedback control algorithm using the plasma control system. It was successfully used to form and maintain nearly exact snowflake configurations for up to 2 s. Pedestal and divertor data analyses are commencing. These experiments laid a foundation for a follow-up snowflake divertor experiment proposed for the DIII-D National Campaign in October 2013.

S. Kaye (PPPL) and D. Smith (U. Wisconsin) participated in a Joint AIP/AAS workshop on Data Accessibility on July 23-24 at the APS Headquarters in College Park, Maryland. The purpose of the workshop was to bring to together several (six) scientists in fusion energy research to discuss issues involved in making published data openly accessible either through the journal of publication or through the home institution's website directly. Guidelines to this effect will shortly be issued by the Department of Energy. Issues such as data accessibility tools, supporting organizations, file structures, citation, peer review and data repositories were discussed. Follow up workshops on metadata and peer review will be held in the Fall.

The ongoing fabrication and power testing of the new firing generators for the field coil power conversion (FCPC) system rectifiers is nearing completion. The last of the 34 planned new firing generators is undergoing pre-operational testing, and communication links between the FCPC rectifiers and the real time control system are being restored.

ADVANCED PROJECTS (H. NEILSON):

The July 26 quarterly meeting of the U.S. Wendelstein 7-X (W7-X) national management team featured a presentation to DOE-Fusion Energy Sciences (FES) program managers of the program

plans for the next four years of the collaboration. This is a critical time period, which will encompass the transition from construction to research on W7-X, including its first two research campaigns. Program leaders from Oak Ridge National Laboratory, Los Alamos National Laboratory, and PPPL presented plans under three themes: Equilibrium, Operations, and Control; Core Transport; and Divertors and Fueling. The first opportunity for physics results from the U.S. participation will arise in a short First Plasma campaign, scheduled for April - June 2015. We will be able to compare U.S. calculations of the effects of trim coils on the magnetic configuration with field mapping measurements, and we will be able to make high-resolution electron and ion temperature profile measurements with a new U.S. x-ray imaging crystal spectrometer (XICS). Thanks to new financial support from FES and a recent series of coordination meetings with the Max Planck Institute for Plasma Physics, the W7-X host, the XICS design effort has already started, with the goal of delivering the equipment to the W7-X site in Greifswald, Germany in time to be available for installation before the First Plasma campaign.

THEORY (A. BHATTACHARJEE):

Dr. Michael Kraus from Max Planck Institute for Plasma Physics, Germany, presented this week's theory seminar entitled "Variational Integrators for Plasma Physics". He introduced the variational integrators scheme which provides a systematic way to derive geometric numerical methods that preserve a discrete multisymplectic form (and therefore have good long time energy behavior) as well as momenta associated to symmetries of the system by Noether's theorem. Good long-time energy behavior with no numerical dissipation was shown for three applications, Vlasov-Poisson system in 1D, and ideal and reduced magnetohydrodynamics in 2D. For Vlasov-Poisson integrators the total particle number, momentum and energy, as well as norms of the distribution function, were exactly conserved. However, for cases when filaments of the order of the grid size were developed, a velocity space collision term was needed to damp the subgrid modes. It was mentioned that the oscillations in energy might be due to the potential term as the advection term similar to Arakawa scheme conserves energy. For ideal MHD, the exact conservation of energy and cross helicity were shown for a current sheet (tanh) set up. Collisionless reconnection from reduced MHD by including electron inertia was also demonstrated with exact conservation properties. Questions regarding the higher dimensionality of this scheme and the conservation property of this scheme compared to other techniques such as discrete finite element Galerkin methods were raised.

A second theory seminar on August 2 was given by Dr. Ido Barth from Hebrew University of Jerusalem on "Autoresonance - A Kinetic Perspective". It was shown that a critical amplitude of the oscillating driving perturbation was necessary for transition to the autoresonace (AR). Two effects, first the AR phase-locking transition of a thermally distributed ensemble, and second the bunching effect due to self fields were discussed. Thermal broadening effect was shown that at temperature T, the capture probability is a smoothed step function of the driving amplitude with the step location and width scaling as alpha^(3/4) (alpha being the chirp rate) and (alpha T)^(1/2), respectively (I. Barth et al . PRL 2009). However, at sufficiently low temperatures this width saturates to a finite value associated with zero point quantum fluctuations. The autoresonance phenomena for a Vlasov-Poisson system was discussed. When the particle density increases, strong repulsive self fields reduce the width of the threshold considerably, as the ensemble forms a localized autoresonant macro-particle. This result played an essential role in the mixing scheme

in anti-hydrogen formation experiment at CERN. Finally, the quantum counterpart of the classical AR phenomenon, i.e. the ladder climbing, and the continuous transition between these two regimes was also addressed (I. Barth, et al. PRL 2011).

ENGINEERING AND INFRASTRUCTURE (M. WILLIAMS):

Construction: Alignment of the upper outer TF weldments continues, and half of the associated shims have been installed. In-vessel welding of the JK stiffeners and the new S-Flip port is underway. Work continues on the PF4/5 support modifications. The welding of all umbrella stiffeners has been completed and inspected. Platform grounding modifications have been completed. In-vessel metrology for the MPTS diagnostic was performed this week.

CS Upgrade: The Centerstack turning fixture was completed at Astro and is expected to arrive at PPPL on August 5. PPPL Engineers travelled to Martinez Inc. to review progress on the OH coil mode, and reported good quality and schedule progress. The fabrication of the OH coil winding station work continued in our Tech Shop. PPPL continues to communicate closely with Everson Inc. on the fabrication of the inner PF coils. Sanding of TF inner quadrants and fit-ups of individual quadrants into the full inner TF mold continued. First fit-ups of all 4 TF inner quadrants are scheduled to start next week.

NBI Upgrade: Installation of cryogenic lines line TTC is back on pace with the resolution of TTC HVAC problems. Fabrication and leakchecking of LHe and LN cryo line continues in the NB shop. The DI water system subcontract continues to make good progress with pipe fitting, welding, and installations in the Pump Room and the MER. A pre-bid conference for the sub-contract installation of NB cable and trays was held with two prospective bidders. The fiberoptic cables to provide communication links between the test cell high voltage enclosures (HVEs) and the D-Site 138" level Local Control Consoles (LCCs) has been received. Alignments of the BL2 90 inch flange has started.

DIRECTOR'S OFFICE (C. AUSTIN):

On August 1, A. Cohen presented to Rutgers students, faculty and summer camp students - an overview about PPPL. He also presented a national laboratory overview at the PPPL Science Education Department Summer Program Seminar.

PUBLICATIONS:

A paper by J. P. Sheehan , I. D. Kaganovich, H. Wang, Y. Raitses, E. V. Barnat, B. R. Weatherford, D. Sydorenko, and N. Hershkowitz, representing collaboration between University of Michigan, Princeton Plasma Physics Laboratory, Sandia National Laboratories, University of Alberta, and University of Wisconsin -Madison and titled "Kinetic Theory of Plasma Sheaths Surrounding Electron Emitting Surfaces" has been accepted for publication in Physical Review Letters. The abstract reads: A one dimensional kinetic theory of sheaths surrounding planar, electron-emitting surfaces is presented which accounts for plasma electrons lost to the surface and the temperature of the emitted electrons. It is shown that ratio of plasma electron temperature

to emitted electron temperature significantly affects the sheath potential when the plasma electron temperature is within an order of magnitude of the emitted electron temperature. The sheath potential goes to zero as the plasma electron temperature equals the emitted electron temperature, which can occur in the afterglow of an RF plasma and some low temperature plasma sources. These results were validated by particle-in-cell simulations. The theory was tested by making measurements of the sheath surrounding a thermionically emitting cathode in the afterglow of an RF plasma. The measured sheath potential shrunk to zero as the plasma electron temperature cooled to the emitted electron temperature, as predicted by the theory. [theory]

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