



The PPPL Highlights for the week ending August 28, 2015, are as follows:

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

The TIP system on ITER must maintain alignment to a few millimeters over a path length of ~80 m. Using a visible laser, researchers at General Atomics have tested the ITER TIP prototype beam line. This system has been designed and constructed over the last eight months to realistically simulate the laser relay system on ITER, including relative motions of various components. Seven separate motions can be independently programmed to simulate motion anticipated between components at installation (room) temperature, operating temperature at 70 degrees Celsius, and bakeout temperatures at 200 degrees Celsius. The system is easily upgradable to also simulate beam motions resulting from expected thermal distortions in the retroreflectors mounted in the outer wall. The next step is to use a CO₂ laser on this beam path, along with beam-positioning and active mirror steering to demonstrate that real time control will maintain alignment of the beam on the retroreflector and on a detector in the presence of these motions. Ultimately, the impact of the motion compensation on interferometer signals will also be studied. These studies will provide valuable information on the sizes of mirrors and windows in the port plug as well.

Proposals were received and evaluation is underway for the ITER reactive power compensators.

NSTX (M. ONO):

J. Menard (PPPL) toured the Tri Alpha Energy facility and attended the Norman Rostoker Memorial Symposium on August 24 in Newport Beach, California and presented a talk entitled "Confinement and stability discoveries from high-beta spherical tori".

Last week was an important moment during the bringing up of the new Multi-Pulse Thompson Scattering (MPTS) configuration, redesigned to support NSTX-U. The initial collection optics alignment, made one year ago before vacuum vessel closing and based on optical landmarks with surveying equipment and mechanical jigs, has been validated with laser Raman scattering. Only a slight tweak was needed. Displacement around the final alignment was documented with a set of dedicated detectors. The new installation includes a set of new near-infrared sensitive cameras, two of which are located behind mirrors bracketing the main laser beam path. A set of laser scattering calibrations was conducted in nitrogen and argon. The alignment documentation was done with Raman scattering in nitrogen. A subset of the work was reproduced in argon in order to measure the bleed-through of the Rayleigh light through the "Raman" filters. Beside Raman scattering in nitrogen, Rayleigh calibrations were also made with both gases.

The drawings and procedure for the electrical installation have been completed for the Materials Analysis and Particle Probe (MAPP). The power to the MAPP electronics rack and the mounting of the cable tray to the diagnostics on the analysis chamber is scheduled for next week.

Completion of the mechanical installation is also expected during that time, when the chiller and vacuum pumps are placed in the NSTX-U Test Cell and connected. This will enable the commissioning of the X-ray photoelectron spectroscopy (XPS) and thermal desorption spectroscopy (TDS) systems. These diagnostics have already been tested when MAPP was installed on LTX. Princeton graduate student Matthew Lucia successfully used them to relate plasma facing surface conditions to discharge performance. He defended his doctoral thesis entitled "Material Surface Characteristics and Plasma Performance in the Lithium Tokamak Experiment" last week.

ITER & TOKAMAKS (R. HAWRYLUK):

DIII-D (R. Nazikian):

S. Haskey has been setting up a synchronous imaging system with the help of Richard Moyer, M. Van Zeeland, and I. Bykor. The aim is to image the EHO, tearing modes, and other higher frequency modes. The system allows modes with frequencies that are orders of magnitude higher than the camera frame rate to be imaged. The technique relies on an input reference signal from a diagnostic such as a magnetic probe. A phase-locked loop is used to generate a reference signal that is 32 times higher in frequency and locked to the reference signal. This upshifted frequency allows accurate gating of an intensifier at any of 32 phases within the mode cycle. By moving from one phase to another at the frame rate of the camera, the high frequency mode is essentially downshifted to the frame rate of the camera. The system is being used in August experiments.

E. Kolemen and D. Eldon developed a real time implementation of SURFMN in the PCS for 3D field control. SURFMN calculates the vacuum resonant field in the plasma that can be used to optimize 3D field control. The code is being carefully debugged and tested in preparation for an ELM controller evening run.

A successful Super Supply Patch Panel (SSPP) FDR was held on August 20 at DIII-D. A. Nagy developed the design and will lead the effort to fabricate the system. The SSPP will enable five power supply systems to connect to three coils sets independently. The patch panel arrangement will be a significant improvement over the present power supply/coil interface and will add capability to power the inner F-coils with bipolar supplies. The I-coils, C-coils, and inner F-coils will be driven by the original SPAs, new Super Supplies from ASIPP, the C-power supplies, and/or the audio amplifiers. The patch panel uses quick disconnect pins without bolts, as with a previously successful patch panel designed and built by Nagy.

Madeline Vorenkamp worked with W. Brown and A. Nagy to test the LGI using carbon granules. The diameter of the piezo gate was reduced to a 1 mm gap, which enabled regulation of the delivery of the carbon granules. The goal is to run both lithium and carbon granules in separate chambers and to be able to switch between them during an experiment. A test with lithium at these settings is being prepared.

G. Kramer visited DIII-D to work with the team to advance understanding of AE instabilities in steady state plasmas. Kramer gave a talk at the science meeting on Friday on the understanding of AE-driven transport and physics-based ideas to reduce fast ion transport in these plasmas. The 20-40% neutron deficit observed in these experiments was reproduced by the modeling taking into account the linear modes from NOVA, the amplitudes from experiment, and the radial displacements from ORBIT; it was integrated into the beam population evolution using NUBEAM in TRANSP. A recipe for reducing AE-induced beam loss was proposed based on moving the location of q_{min} to a larger radius. This could be achieved transiently by faster current ramps and may be sustained steady state with increased off-axis current drive.

A. Boozer visited DIII-D to discuss with the 3D Stability group the interpretation of the plasma multimode response. Very effective discussions took place on the nature of stable ideal MHD modes and how they respond to external non-axisymmetric fields.

C-Mod (S. Scott):

New software for the Multi-Spectral Line Polarization (MSLP) MSE diagnostic has been completed and is currently undergoing debugging. The software allows the measurement of partially polarized light at wavelengths near the MSE spectrum to be subtracted in real time from the beam-generated signal, thereby improving measurement accuracy in situations where the background light changes rapidly in time. Although the MSLP diagnostic has four times as many channels as the original MSE diagnostic, the new software requires only ~1% of the previous memory. The new software is highly modular, is entirely driven by analysis parameters stored in the C-Mod MDSPLUS tree, and is action-driven following a C-Mod shot cycle. The overall code architecture is designed to allow the C-Mod MSLP-MSE diagnostic to be easily ported to another tokamak facility.

ADVANCED PROJECTS (H. NEILSON):

The Laboratory is working with the Institute of Plasma Physics of the Chinese Academy of Sciences (ASIPP) on a concept study for a proposed China Fusion Engineering Test Reactor (CFETR). PPPL's participation, which is funded by ASIPP under a Strategic Partnership Project agreement, focuses on the exploration of enhanced capabilities for the CFETR in a second phase of operation. In a joint ASIPP-PPPL project meeting this week, C. Kessel reported preliminary systems analysis of CFETR Phase II configurations, with the aim of assessing the most promising directions for Phase II design improvements. It was shown that improvements in plasma energy confinement, operation above the Greenwald density limit, increased thermal conversion efficiency, and increased magnetic fields are all beneficial, but that divertor heat flux is a significant limiting factor to higher fusion and auxiliary power solutions. ASIPP's Professor Songlin Liu reported progress in the design of a water-cooled ceramic breeder blanket for CFETR Phase I. Neutronics analysis is used to optimize the radial build of each blanket module to achieve maximum tritium breeding ratio within the temperature limits of constituent materials. P. Titus reported on the status of PPPL preparations to perform selected thermofluid and magnetic analyses to provide an independent check on ASIPP's analyses. This work deepens understanding of the multi-physics, multi-materials behaviors in fusion blankets.

THEORY (A. BHATTACHARJEE):

This week a Theory Department Research and Review seminar was given by S. Ku, entitled “A new Lagrangian particle scheme utilizing phase space grid for XGC1 edge gyrokinetic code”. The abstract reads: “A new Lagrangian numerical scheme has been developed that utilizes the phase space grid in addition to the usual marker particles. The new scheme splits the probability distribution function (PDF) of a kinetic equation into PDF of weighted particles and PDF of phase space grid. The former contains the fast varying part of the whole PDF and the later mostly contains the slowly varying part. The numerical scheme is implemented in the gyrokinetic particle code XGC1, which specializes in simulating the tokamak edge plasma. Since edge plasma across the magnetic separatrix and in contact with the wall is in non-thermal equilibrium with sources and sinks, the conventional delta-f technique is inapplicable. Deviation of the slowly varying PDF on velocity grid can be arbitrarily large. The weights of marker particles are determined by ‘direct weight evolution’ instead of the differential form of weight evolution equations that conventional delta-f schemes use. Particle weight is slowly transferred to the phase space grid, suppressing the growth of particle weights. Comparison with the usual full-f and delta-f method confirms validity of the new scheme. The new scheme is compatible with massively parallel computing.”

D. E. Ruiz and I. Y. Dodin published a paper titled "Lagrangian geometrical optics of nonadiabatic vector waves and spin particles" [Phys. Lett. A 379, 2337 (2015)], which discusses a fundamental extension of geometrical optics for vector waves and quantum particles. Linear vector waves, both quantum and classical, experience polarization-driven bending of ray trajectories and polarization dynamics that can be interpreted as the precession of the "wave spin". Both phenomena are governed by an effective gauge Hamiltonian vanishing in leading-order geometrical optics. This gauge Hamiltonian can be recognized as a generalization of the Stern-Gerlach Hamiltonian that is commonly known for spin-1/2 quantum particles. The corresponding reduced Lagrangians for continuous nondissipative waves and their geometrical-optics rays are derived from the fundamental wave Lagrangian. The resulting Euler-Lagrange equations can describe simultaneous interactions of N resonant modes, where N is arbitrary, and lead to equations for the wave spin, which happens to be an $(N^2 - 1)$ -dimensional spin vector. As a special case, classical equations for a Dirac particle ($N = 2$) are deduced formally, without introducing additional postulates or interpretations, from the Dirac quantum Lagrangian with the Pauli term. The model reproduces the Bargmann-Michel-Telegdi equations with added Stern-Gerlach force. C. Liu and Dodin published a paper titled "Nonlinear frequency shift of electrostatic waves in general collisionless plasma: unifying theory of fluid and kinetic nonlinearities" [Phys. Plasmas 22, 082117 (2015)]. In that paper, the nonlinear frequency shift is derived in a transparent asymptotic form for intense Langmuir waves in general collisionless plasma. The formula describes both fluid and kinetic effects simultaneously. The fluid nonlinearity is expressed, for the first time, through the plasma dielectric function, and the kinetic nonlinearity accounts for both smooth distributions and trapped-particle beams. Various known limiting scalings are reproduced as special cases. The calculation avoids differential equations and can be extended straightforwardly to other nonlinear plasma waves.

PLASMA SCIENCE AND TECHNOLOGY (P. EFTHIMION):

M. Lucia successfully defended his thesis for a doctorate in the Program in Plasma Physics of the Department of Astrophysics at Princeton University. Its title was “Material Surface Characteristics and Plasma Performance in the Lithium Tokamak Experiment”. The details of the relationship between the characteristics of plasma-facing components (PFCs) and discharge performance have been difficult to determine. This is because the characteristics of PFCs during plasma operations are typically inferred after they are removed and analyzed at the end of the run. Lucia was able to avoid this problem by using the Materials Analysis and Particle Probe (MAPP), a diagnostic system developed by Purdue University and the University of Illinois at Urbana-Champaign. Lucia was able to implement MAPP on the Lithium Tokamak Experiment (LTX) in collaboration with researchers from these institutions. He was able to expose PFC samples to LTX plasmas and withdraw them into a chamber for surface analysis without breaking vacuum. Using x-ray photoelectron spectroscopy (XPS) and thermal desorption spectroscopy (TDS), Lucia was able to obtain unique data on the ability of lithium coatings to retain impurities and hydrogen and relate them to changes in LTX discharge parameters.

BUSINESS OPERATIONS (K. FISCHER):

Budget Office:

NSF provided third-year funding in the amount of \$100,000 for the Strategic Partnership Project titled “GEM: Modeling How Substorm Induced Waves Power Broadband Aurora”. The Principle Investigator for this effort is J. Johnson.

A proposal was submitted to NASA titled “Study of Equilibrium Force Balance and Eruptive Instabilities of Solar-relevant Flux Ropes”. The proposal is requesting three years of funding in the amount of \$601,773. The Principle Investigator for this project is W. Fox.

A proposal was submitted to NASA titled “Laboratory Experiment on the Magnetic Reconnection Layer Supporting the Magnetospheric Multiscale Mission (MMS)”. The proposal is requesting funding for three years in the amount of \$670,178. The Principle Investigator for this proposal is M. Yamada.

A one-year renewal proposal covering FY16 was submitted to the Department of Energy for the collaborative SciDAC project titled "Center for Nonlinear Simulation of Energetic Particles in Burning Plasmas (CSEP)". The PPPL funding request is \$245,000; the Principal Investigator is G. Fu.

DIRECTOR’S OFFICE (C. AUSTIN):

On August 14-16, S. Prager served on an advisory committee for the Space Physics Research Facility at the Harbin Institute of Technology, China, and on August 17 visited the institute of Plasma Physics and the University of Science and Technology of China in Hefei.

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