Weekly HIGHLIGHTS

PPPL PRINCETON PLASMA PHYSICS LABORATORY

U.S. DEPARTMENT OF ENERGY

The PPPL Highlights for the week ending May 26, 2017 are as follows:

U.S. ITER FABRICATION (H. NEILSON):

Steady State Electrical Network (J. Dellas):

With assembly of the first uninterruptible power supply (UPS) system and the DC Distribution network having been completed, testing of this equipment is now underway. Factory acceptance testing of these items is scheduled to be conducted in June.

Diagnostics (R. Feder):

Electron Cyclotron Emission (ECE) and port integration: A peer review of the ECE an in-situ calibration source was conducted, validating the current design intents for integrating in-vessel ECE components in Equatorial Port 09. The calibration source is basically a controlled radiator that will be used to calibrate the ECE system.

Toroidal Interferometer/Polarimeter (TIP): The ITER toroidal interferometer / polarimeter requires a retroreflector, an in-vessel component that is specially designed to reflect the microwave beam, after one pass through the plasma, back through the plasma along the same path. This allows microwave transmission and reception to be accomplished by the same antenna. An aluminum pre-prototype of the TIP channel 2 retroreflector, manufactured by SPAWR Industries delivered an aluminum pre-prototype of the TIP channel 2 retroreflector was delivered to the Laboratory, along with a draft Manufacturing, Inspection, and Testing Plan (MIT). Delivery of a molybdenum prototype is expected in 2 months.

NSTX-U RECOVERY PROJECT (R. HAWRYLUK):

Evaluations of NSTX-U test cell penetrations were made this week using a neutron generator staged at various locations around the machine. Data is being reviewed, and will be used for developing shielding improvements. Initial interpretation of the data suggests that ~13 penetrations cause most of the dose outside of the test cell.

A procedure is being prepared to perform in-situ impedance vs. frequency measurements of the NSTX-U OH coil for consideration in a design study to provide inductive heating of the machine's center column as driven by the OH central solenoid.

Recommissioning of the coil winding facility continued this week with the receipt of freshly cleaned and primed PF inner conductor, which has been loaded unto a metal spool. Testing of the conductor hold-down clamp and commissioning of the vacuum lead box is in progress. A decision to fabricate the PF-1A coils without mandrels have been made to facilitate testing prior to installation. The design of the PF-1A prototype is being modified so that the Prototype procurement package can be expedited.

Voith Hydro has completed the cleaning of the Motor Generator (MG#1) bearing journal, and preparations are underway to reassemble the lower guide bearing. Initial borescope inspections of the MG#1 stator core have been completed.

The three rebuilt neutral beam (NB) Helium Cryo-plant compressors are in place and being aligned. Also, the rebuilt NB autotransformer and tap changer assembly is back on site and is being prepared to be lifted into the switchyard.

NSTX-U RESEARCH (J. MENARD):

M. Ono was invited to attend the "All-about- Divertor " meeting held at the National Institute for Fusion Science (NIFS), Gifu, Japan, May 25 - 26. He gave an invited overview talk (also the NIFE laboratory seminar) entitled "NSTX-U Initial Operations and Liquid Metal-Based Divertor Research and Development in the US." During the visit, he met with a number of researchers including Professors Hirooka, Muraga, Tamura, and Kunugi, and visited the liquid metal facilities at NIFS and Kyoto University. He also visited the LHD Control Room during plasma operation.

ITER & TOKAMAKS (R. NAZIKIAN):

International:

F. Poli participate in the recent JET DT modeling campaign to benchmark the new NTM module in TRANSP and a European NTM module for scenario development on JET. A JET report summarizing this activity will be completed in June. TRANSP will be used to design JET DT discharges for the upcoming DTE2 campaign in FY19. The TRANSP analysis will be used to optimized current ramp-up, heating, current drive and MHD stability for access to high confinement H-mode with reduced high-Z impurity content.

DIII-D:

A paper titled: "Improving fast-ion confinement in high-performance discharges by suppressing Alfven eigenmodes" by G.J. Kramer at al. was published in Nuclear fusion. In this paper, it is shown that the degradation of fast-ion confinement in steady-state DIII-D discharges is quantitatively consistent with predictions based on the effects of multiple unstable Alfven eigenmodes on beam-ion transport. Simulation and experiment show that increasing the radius where the magnetic safety factor has its minimum is effective in minimizing beam-ion transport. This is favorable for achieving high performance steady-state operation in DIII-D and future reactors.

A new feeder unit for the PPPL impurity powder dropper has successfully completed a series of tests. The previous version suffered from large variations in the drop rate due to the changing mass and resonant frequency of the dropper unit as the contents of the feeder decreased. The issue was overcome by installing a separately mounted tube above the feeder funnel. A powder drop rate calibration was produced for boron nitride. Robustly reproducible drop rates of 5 mg/s to 250 mg/s were achieved. This achieves a key goal for the new dropper development, to be installed on DIII-D for the upcoming NSTX-U campaign.

I. Satz held a successful neutral beam calorimeter final design review this week with GA and DIII-D engineers. A novel feature of the design is a gun drilled perimeter coolant channel, which prevents thermal fatigue and cracking from thermal cycling. This solves a design issue with the original calorimeter, which led to thermal fatigue cracking after a 30- year period. The calorimeter delivery to GA is expected at the end of September this year.

ADVANCED PROJECTS (H. NEILSON):

Stellarators (D. Gates):

S. Hudson and S. Lazerson attended the 1st Journal of Plasma Physics Frontiers in Plasma Physics Conference held in Spineto, Italy, 24-26 of May. Hudson gave a presentation on a new multi-region, relaxed-ideal MHD energy principle and had various discussion with staff from the Max Planck Institut for PlasmaPhysik regarding advanced and exotic stellarator designs; and S. Lazerson gave a presentation entitled "From tokamaks to stellarators: the role of three dimensional shaping." describing how non-axisymmetric shaping affects quasi-symmetry. Dr. Lazerson's presented an overview of a draft paper, in which Lazerson discusses both how shaping is used to drive rotational transform and metrics for designing stellarators which are robust to toroidal currents.

On May 24, Novimir Pablant gave an invited talk at the International Conference on Plasma Science (ICOPS 2017) in Atlantic City, New Jersey. The talk was entitled "Investigation of Core Transport during the First W7-X Experimental Campaign", and served as an overview of the results from the W7-X experiment, and a highlight of United States contributions.

THEORY (A. BHATTACHARJEE):

On May 22, a paper entitled "Nonlinear Reconnecting Edge Localized Modes in Current-Carrying Plasmas" by F. Ebrahimi was published [Phys. Plasmas 24, 056119 (2017). This is the first paper that sheds light onto the role of reconnection in the nonlinear dynamics of edge-localized modes (ELMs) in tokamaks. The longstanding problem of quasiperiodic ELMs cycles is explained though the edge reconnection process. Using 3-D resistive MHD simulations, it is shown that in the presence of resistivity, physical current layers developing near the plasma edge can be unstable to 3-D current-sheet instability. We show coherent current-carrying filament (ribbon-like) structures (sometimes referred to as 3-D plasmoids) wrapped around the torus that are nonlinearly formed due to nonaxisymmetric reconnecting current sheet instabilities, the so called peeling-like edge localized modes. These fast growing modes saturate by breaking

axisymmetric current layers isolated near the plasma edge and go through repetitive relaxation cycles by expelling current radially outward and relaxing it back. For the first time, it has been shown that low-n edge localized structures (1) have reconnecting nature, and (2) have a finite localized fluctuation-induced bi-directional emf dynamo term, which could cause the local annihilation of axisymmetric current (current holes) near the edge region in the nonlinear stage. It is also found that the current-driven edge modes alone (an important component of ELMs), without the pressure-driven component, are sufficient to explain the quasiperiodic cycles along with the rapid relaxation of edge current. Our simulations also show the existence of nonaxisymmetric total toroidal current density filament in the edge region (both around the separatix and the open field line regions).

On May 25, R. Kulsrud (PPPL) presented a theory seminar on Anomalous Diffusion across a Tera Gauss Field in accreting Neutron Stars. A large amount of mass falls on the polar region of neutron star in Xray binaries and the question is, is the mass completely frozen on the field lines or can it diffuse through them? In this talk we present a mechanism for the latter possibility. A strong MHD instability occurs in the top layers of the neutron star driven by the incoming mass. This instability has the same properties as the Schwarzschild instability in the solar convection zone. It gives rise to a turbulent cascade, which mixes up the field lines so that lines originally far apart can come with a resistivity diffusion distance and transfer the masses between them. However, the lines of force themselves are not disrupted. This leads to an equilibrium, which is marginal with respect to the instability just as happens in the Schwarzschild case.

On May 26, Leonid Zakharov (LiWFusion) presented a theory seminar on "Hot Particle Equilibrium code (HPE) with plasma anisotropy and toroidal rotation". The HPE code represents the extension of ESC (Equilibrium and Stability Code) to tokamak equilibria with plasma anisotropy and toroidal rotation. In addition to conventional 1-D input profiles of plasma pressure p(a) and safety factor q(a), HPE accepts the poloidal Mach number, M(a), of plasma rotation and 2-D parallel pressure profile of hot particles, $p_{\parallel}(a,B)$, as the input. Here, a is the normalized radial flux coordinate of magnetic configuration and B is the strength of magnetic field. The HPE code includes the effect of finite width of hot particle orbits and for the case of powerful NBI injection the code can generate the plasma equilibria for theory needs as well as use the experimental (or kinetic simulations) data for interpretation of experiments.

S. Hudson, M. Kunz and G. Hammet attended the Journal of Plasma Physics Frontiers in Plasma Physics Conference held in Spineto, Italy, 24-26 of May. Hudson gave a presentation on a new multi-region, relaxed-ideal MHD energy principle; and M. Kunz spoke about MRI turbulence and dynamo in a collisionless plasma and Dissipation-range kinetic turbulence in pressure-anisotropic astrophysical plasmas.

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