

NSTX-U Weekly Report (November 27, 2013)

NSTX-U is in the Upgrade Project outage in FY 2013

The paper "Measurements and simulations of low wavenumber pedestal turbulence in the National Spherical Torus Experiment" by D. R. Smith (UW-Madison) et al. was published in Nucl. Fusion 53, 113029 (2013). The paper 1) reports BES measurements of H-mode pedestal turbulence fluctuation amplitudes, 2) applies an ensemble machine learning algorithm to identify parametric scalings for fluctuation amplitudes, and 3) reports pedestal turbulence simulations with full-pedestal domains. Fluctuation amplitudes at $r/a=0.84-0.96$ in the steep gradient region are in the range 1.2-4.7%. Modeling results from the machine learning algorithm indicate fluctuation amplitudes increase at higher density gradient, collisionality, and beta; fluctuation amplitudes decrease at higher magnetic shear and Ti gradient. Most notably, the scalings are inconsistent with ITG turbulence, but are partially consistent with TEM, KBM, and microtearing. The measurements and scalings are consistent with previous measurements and scalings reported in PoP 20, 055903 (2013). GEM linear gyrokinetic simulations by S. Parker and W. Wan at UC-Boulder with full-pedestal profiles indicate the unstable modes are collisional with mixed-parity mode structure, consistent with observations. In addition, linear growth rates increase at higher density gradient and decrease at higher Ti gradient, in qualitative agreement with observations. Finally, BOUT++ nonlinear Braginskii fluid simulations could not reproduce observed turbulence properties, which is not surprising given the physics contained in Braginskii fluid model. The Braginskii fluid simulations highlight the importance of electron dynamics for pedestal turbulence, and underscore the need for gyrokinetic or gyrofluid simulations of pedestal turbulence. (D. Smith)

A paper titled "Dependence of the L-H transition on X-point geometry and divertor recycling on NSTX" by Devon Battaglia (PPPL) et al., has been published in Nuclear Fusion (vol 53, page 1130132). The paper describes results from targeted experiments on NSTX to decouple the dependence of the L-H transition on divertor recycling and the X-point radius. It is observed that the L-H power threshold decreases as the X-point is moved to larger major radius (lower triangularity) and as the neutral fueling provided from divertor recycling decreases via lithium condition of the first wall. The significant observation is that the edge temperature at the time of the L-H transition depends on the X-point radius, but is independent of the neutral fueling source and edge density. This result is in agreement with the prediction that the kinetic neoclassical transport, including ion orbit loss, sets the edge radial electric field and the ExB shear available to sustain the H-mode transport barrier. This theory is tested quantitatively using full-f self-consistent XGC0 simulations of the kinetic neoclassical transport in the L-mode edge, which show excellent agreement with the observed trends with X-point radius and divertor recycling. (D. Battaglia)

NSTX-U research on liquid lithium plasma-facing components was featured in an APS press-release, <http://www.aps.org/units/dpp/meetings/vpr/2013/index.cfm>. The research, led by M. Jaworski (PPPL), was carried out in collaboration with the Dutch Institute for Fundamental Energy Research (FOM-DIFFER) in the Netherlands. Experiments were conducted on the linear plasma device Magnum-PSI that mimics divertor densities and temperatures and produces heat-fluxes similar to those expected in the NSTX-U divertor. A candidate material for the NSTX-U high-Z divertor upgrade, the molybdenum alloy TZM, was tested with and without thin lithium coatings (1 micron thick) applied in-vacuum during these experiments. Lithium was

applied via evaporation using a prototype evaporator developed for use on the NSTX. In these experiments, the samples tested reached temperatures of approximately 1300C during 7s exposures to the Magnum-PSI plasma - a temperature range similar to that expected in the NSTX-U divertor. Initial estimates of the lifetime of the lithium coatings indicated that as little as 0.5s might be expected in the absence of redeposition of the eroded material onto the TZM substrate. During the course of the tests, however, the coating was found to persist for 3-4s indicating significant redeposition. These exposures resulted in the production of a cloud of lithium vapor directly in front of the TZM target that remained stable during the 3-4 seconds that macroscopic layers of lithium were present. The experiments already indicate that usage of evaporated layers of only 1 micron thickness of lithium in the NSTX-U may have similar lifetimes allowing early research on vapor-shielded targets in advance of the deployment of fully flowing liquid lithium systems in the NSTX-U. (M. Jaworski)

The APS Invited Talk, "Physics of fast flux closure in Coaxial Helicity Injection (CHI) experiments in NSTX," by Fatima Ebrahimi (PPPL/Princeton University) was highlighted in a APS DPP Press Release "Building a Better Tokamak by Blowing Giant Plasma Bubbles" – <http://www.aps.org/units/dpp/meetings/vpr/2013/upload/ebrahimi.pdf>. These studies carried out using the 3-D NIMROD code, describe the mechanisms for the generation of closed flux surfaces in NSTX transient CHI discharges. Although CHI is believed to be a 3-D process, the simulations show that the NSTX CHI experiments could be described by 2-D Sweet-Parker type reconnection and have some universal aspects such as the process that produces solar flares. These experiments also represent the first-ever occurrence of *forced* magnetic reconnection during transient CHI discharges on a large-scale fusion facility. (F. Ebrahimi)

"Fusion foe lends a helping hand" was featured in an APS press-release: <http://www.aps.org/units/dpp/meetings/vpr/2013/upload/taylor.pdf>. The talk and paper corresponding to this press release were, "Differentiating the role of lithium and oxygen in retaining deuterium in lithiated graphite plasma-facing components" by Chase Taylor (INL) and JP Allain (UIUC). In this paper, surface oxygen was shown to contribute more strongly to deuterium retention than lithium. However, the graphite tiles cannot maintain high enough oxygen concentration needed to retain deuterium without lithium. Accordingly, lithium is a necessary ingredient that getters the oxygen required to retain deuterium. (C. Taylor)

Engineering Operations (A. von Halle, C. Neumeyer)

NSTX Upgrade activities continued with the ongoing preparation of the OH winding system. Test pulls of the OH conductor from the reel are going well, and the winder and taping machines are working in sync. On track to start the actual OH coil winding next week. In the NSTX Test Cell, mapping of all in-vessel diagnostics is in progress and a general arrangement drawing will be generated. Fit-up/Installation of the in-vessel NB armor continues.

Preparations for plasma operations in the NSTX-U configuration also continued with the commissioning of new Field Coil Power Conversion (FCPC) rectifier controls. New fiber-optic cable runs from the NSTX Test Cell to the FCPC Junction Area have been installed and are currently being terminated.

Access to the NSTX test cell will be available only through previous arrangement with the Upgrade Work Control Center.