

NSTX-U Weekly Report (August 5, 2016)

FY 2016 NSTX plasma operations completed
Completed: 10.06 run weeks and 1066 plasma shots

A paper entitled "Kinetic corrections from analytic non-Maxwellian distribution functions in magnetized plasmas" by O. Izacard (LLNL, assignment at PPPL) has been published in *Physics of Plasmas* **23**, 082504 (2016) ([dx.doi.org/10.1063/1.4960123](https://doi.org/10.1063/1.4960123)) containing some results presented at the Nat. Fisch's Symposium (PPPL, March 2016). This work uses the well known Kappa distribution function and the sum of 2 Maxwellian distribution functions (MDFs) for the description of non-Maxwellian distribution functions (NMDFs). In addition, an interpreted analytic non-Maxwellian called INMDF has been constructed from new non-orthogonal basis sets. The physical and experimental existence of INMDFs is proved particularly by new understandings of the electron temperature discrepancy between ECE and TS diagnostics in JET and TFTR. The advantage of using an analytic NMDF is shown in the paper by our ability to analytically compute velocity phase space integrals resulting in a small number of simple terms as function of the fluid parameters of the NMDFs. As applications, we show the effects of different super-thermal tails on the secondary electron emission, the Langmuir probe characteristic curve and the entropy. As main results, it is shown that (i) the empirical formula for the secondary electron emission is not consistent with a MDF due to the presence of super-thermal particles, (ii) the super-thermal particles can replace a diffusion parameter in the Langmuir probe current formula, and (iii) the entropy can explicitly decrease in presence of sources only for the introduced INMDF without violating the second law of thermodynamics. Some of these results can be used for better interpretations of NSTX-U Langmuir probes and other diagnostics in presence of NMDFs. Finally, new techniques can be developed in NSTX-U for the measurement of NMDFs. (O. Izacard)

The Finite-orbit-width (FOW) extensions for the CQL3D bounce-average Fokker-Planck code have been developed in the past few years. Last month, an extensive manuscript has been submitted to PPCF with detailed description of the theoretical formulation and initial verification tests in conditions of NSTX plasma with NBI and HHFW heating [*"A Fully-Neoclassical Finite-Orbit-Width Version of the CQL3D Fokker-Planck code"* by Yu.V. Petrov and R.W. Harvey; available as a CompX report from <http://www.compxco.com/cql3d.html>]. The calculations for the ionic portion of the bootstrap current show a good match with [Sauter et al] fit model equations in the plasma core, and there is a noticeable difference at the plasma edge region where the ion orbital+gyro losses become significant. The focus of the tests was the fully-neoclassical radial transport from both collisions and the quasilinear diffusion by RF waves, particularly at high-energy non-Maxwellian region of the deuterium distribution function. (Y. Petrov, CompX)

Several PPPL researchers attended the Fusion Materials /Plasma Wall Interaction PI meeting July 25-29, 2016 at UTK in Knoxville and at ORNL. C. Kessel gave a talk on '*FNSF/Design Team Overview and Material R&D Needs*'; E. Kolemen gave a poster on '*FLIT: Flowing Liquid metal Torus*'; M. Jaworski gave a review of '*Liquid Metals as Plasma Facing Components: Progress and Prospects*'; C. Skinner gave the *PPPL Institutional Overview* including results from NSTX, LTX and Surface Science; M. Jaworski gave a presentation on '*International Collaborations and Device Exploitation*'; and R. Majeski gave a talk on '*Deployment Issues in Flowing Liquid Plasma Facing Material systems*'. Discussions highlighted the need for R&D on

liquid metal corrosion issues, ways to separate lithium and hydrogen (tritium) after plasma exposure, and the stability of thick flows of liquid metals. All the presentations will be posted on the VLT website <http://web.ornl.gov/sci/vlt/> in the near future. (C. Skinner)

R. Maingi (PPPL) presented a seminar at the Nuclear, Plasma and Radiological Engineering Dept. at the Univ. of Illinois: "The effect of lithium on Edge Plasma Performance and Stability in NSTX". Lithium collaborations between NSTX-U and UI-UC were also discussed. (R. Maingi)

A Conceptual Design Review for the NSTX-U Cryo-pumped Divertor (CPD) was held at PPPL on August 3, 2016. Programmatic justification and physics motivation and design of the CPD was described by J. Menard and S. Raftopoulos described CPD Project Management and the overall system description and safety considerations. N. Atnafu gave an overview of the Systems Requirements Document, R. Vieira (MIT) described the design of the cryo-ring/pump, T. Stevenson described the planned CPD connections to the cryo-plant and new He refrigerator, M. Mardenfeld described the conceptual design of the CPD support structures, baffle plates, bakeout needs, and PFCs. S. Gerhardt described the diagnostics, PFC sensors and plasma viewing, and S. Langish gave a presentation describing the cost, schedule and manpower needs for the project. (J. Menard, S. Raftopoulos, PPPL)

Engineering Operations (A. von Halle, P. Titus)

Post-run calibrations were performed this past week in preparation for the NSTX-U outage. Magnetic diagnostic calibration shots have been completed, and several shots supporting the Motional Stark Effect Laser Induced Fluorescence (MSE-LIF) calibration utilizing the Diagnostic Neutral Beam (DNB) injection into a gas filled torus were performed. Multi-pulse Thomson Scattering (MPTS) diagnostic Rayleigh and Raman calibrations have been completed. The neutral beam (NB) cryo-panels have been warmed to room temperature, and the helium refrigerator secured. An internal water leak has been detected in NB#1 and preparations are underway to sample/recover the accumulated water and make the needed repair. Hydrostatic tests of the PF coils have been successfully completed, and low frequency PF coil impedance measurements are scheduled for early next week. Also this week, the conceptual design of the proposed NSTX-U Divertor Cryo-Pump was reviewed with the help of experts from MIT and General Atomics.

The NSTX-U Test cell will be in restricted access this coming week during diagnostic calibrations and field coil measurements. Limited access is expected to be available for approved work on second shift.

Run Coordination (J. Menard, S. Gerhardt)

On Wednesday July 27, about 11 beam-into-gas shots were taken under XMP-157 (Characterization of neutral beam fractions). The Fast Ion D-Alpha (FIDA) spectrometers and fast cameras were used to measure spectra in the D-alpha wavelength range and to take images of D-alpha emission respectively. A scan of neutral beam source, injection energy and background pressure is performed. The data is very useful for the check of v-FIDA and t-FIDA spectra response and assessment of beam emission signals to assist the design of "D-alpha monitor" system. Initial data analysis shows that the active t-FIDA system has observed Doppler shifted D-alpha signal from three energy components of neutral beam line 1, as expected. More

detailed analysis is underway to estimate beam species of three energy components as a function of beam injection energy. (M. Podesta, PPPL, D. Liu, UCI)