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Diagnostics for lithium age on NSTX

V. A. Soukhanovskii

Lawrence Livermore National Laboratory

H. W. Kugel, R. Kaita, A. L. Roquemore

Princeton Plasma Physics Laboratory

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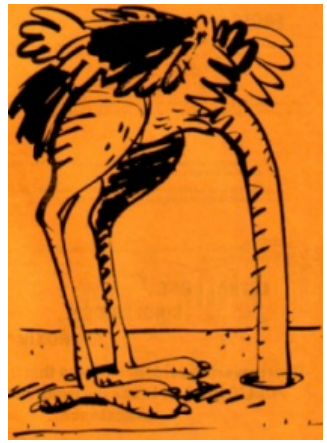
NSTX is implementing a staged approach to test lithium effects on plasma performance

- **Stage 1 - Lithium pellet injector**
- **Stage 2 - Lithium evaporator**
- **Stage 3 - Lithium divertor module**

- **CDX-U operation with Li and NSTX Li experiments demonstrated a preview of lithium age**

- **In this talk: Lithium age = liquid lithium divertor**

- **Diagnostic needs for lithium age on NSTX**
  - Impact on existing diagnostics
    - Secure existing diagnostics
    - Replace some diagnostics
  - Special diagnostics to study lithium effects



Measurements and their interpretation can be affected by lithium unless special care is taken

- Direct effect on measurements due to **lithium deposition**
  - Degradation of **window** transmission and **mirror** reflectivity
    - Impact on photometrically calibrated diagnostics (MPTS, CHERS, spectroscopic detectors and cameras)
  - Li coatings may be a problem for **exposed diagnostic parts**
    - Examples: flush-mounted Langmuir probes, SXR array foil filters, exposed detectors
  - **Change in measured parameter range** due to Li pumping
    - Examples: neutral pressure, density, recycling

- Effect due to wrong measurement **interpretation**
  - **Reflections** from liquid lithium surface or Li-coated surfaces complicate interpretation of some measurements
    - Examples: IR camera measures IR emissivity of carbon tile surface, filtered cameras measure edge emission

- **This list is not complete -** other effects on diagnostics, on plasma operations ?

Lithium pellet injector and lithium evaporator experiments demonstrated the benefit of addressing diagnostic issues in a timely manner

- **Just some examples…**

- **Fast optical observations of Li and C pellets**
  - Purchased Li I and Li II filters for fast cameras to observe pellet propagation
  - Instrumented fast (~ 10 kHz) filtered visible detectors (EIES) with views of pellet trajectory

- **Spectroscopic measurements of recycling, lithium deposition and impurities**
  - Instrumented filtered (D_α, C II, CIII, Li) cameras viewing divertors and CS
  - Testing Ly-alpha arrays (in collaboration with LTX)
  - XEUS impurity spectrometer

Particle and density control using lithium will be one of the main research thrusts on NSTX

- **Running NSTX with a liquid lithium divertor module means a new edge characterization**

- **From a Boundary Physics prospective:**
  - **Characterize particle balance, fueling and pumping**
    - Particle flux measurements - neutral and impurity sources and sinks
    - Particle balance using integrated edge and core modeling (e.g. DEGAS 2, UEDGE + TRANSP)
  - **Characterize impact on transport regimes**
    - Impurity and neutral profiles
    - Ion temperature and rotation profiles
  - **Characterize divertor performance**
    - Divertor heat flux handling
    - Divertor pumping, neutral pressures
    - MARFE formation
    - Role of molecular fluxes in fueling (D_2, hydrocarbons, dimers)

Success of LLD operation will depend in part on diagnostic measurements

- **Initial plan may include:**
  - Identify impact of LLD operation on
    1) NSTX diagnostics
    2) facility and plasma operations
  - Develop plan for required measurements and diagnostics to accomplish LLD mission and LLD-related milestones
    - Depends on LLD location
    - Need for vacuum vessel modification?
    - Depends on LLD goals, milestones,
    - …
  - CDX-U and LTX experience is valuable
- **Are NSTX diagnostic preparations a budgeted item ?**

Diagnostic	Impacted by LLD?
Bolometer – tangential array	
Bolometer – divertor	
CHERS – toroidal	?
CHERS – poloidal	?
Divertor fast camera	X
Dust detector	?
EBW radiometers	
Edge deposition monitors	
Edge pressure gauges	?
Edge rotation diagnostic	?
Fast ion D_alpha - FIDA	?
Fast lost ion probes - IFLIP	
Fast lost ion probes - SFLIP	
Filterscopes	X
FIReTIP	
Gas puff imaging	X
Hα camera - 1D	
High-k scattering	
Infrared cameras	X
Interferometer - 1 mm	
Langmuir probes - divertor	X
Langmuir probes – RF antenna	X
Magnetics – Diamagnetism	
Magnetics - Flux loops	
Magnetics - Locked modes	
Magnetics - Pickup coils	
Magnetics - Rogowski coils	
Magnetics - RWM sensors	
Mirnov coils – high frequency	
Mirnov coils – poloidal array	
Mirnov coils – toroidal array	
MSE	?
NPA – ExB scanning	
NPA – solid state	
Neutron measurements	
Plasma TV	X
Reciprocating probe	?
Reflectometer – 65GHz	
Reflectometer – correlation	
Reflectometer – FM/CW	
Reflectometer – fixed f	
Reflectometer – SOL	
RF edge probes	
Spectrometer – SPRED	
Spectrometer – VIPS	X
SWIFT – 2D flow	
Thomson scattering	X
Ultrasoft X-ray arrays	?
Ultrasoft X-ray arrays – bicolor	?
Ultrasoft X-rays – TG spectr.	
Visible bremsstrahlung det.	X
X-ray crystal spectrometer - H	
X-ray crystal spectrometer - V	
X-ray fast pinhole camera	

Diagnostic ideas for measurements important in Lithium age on NSTX

- **Divertor particle flux (recycling) measurements in lithium environment** - Ly-alpha arrays
- **Divertor particle (atomic and molecular) fluxes, ion temperature, electron temperature and density** - imaging UV-VIS divertor spectrometer
- **Divertor heat flux measurements** - thermocouples, divertor tile fiber-based IR thermography, in-situ calibration techniques for IR cameras
- **Divertor physics** - multi-point divertor Thomson scattering system
- **Particle transport, confinement** - main plasma lithium density profile - soft X-ray arrays
- **Particle transport, confinement, fueling** - main plasma & pedestal neutral profile - laser-induced photoionization diagnostic