"NSTX Module A Erosion/Redeposition Analysis"

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NSTX Lithium Module A
Erosion/Redeposition (Preliminary) Analysis

- Module A = static lithium on divertor (Majeski et al.)

- Purpose: integrated WBC/UEDGE analysis of lithium transport in SOL, define effect on NSTX plasma, establish plasma operational limits (NBI + RF power, density limits, etc.)

NSTX Lithium Module A
Erosion/Redeposition (Preliminary) Analysis

- ***REDEP/WBC code simulation of 8 cm poloidal by 2πR = 5.366 m full-toroidal static lithium module. Moderate-power/low-density SOL plasma case.***

- *Using 2-D plasma parameters/profiles from UEDGE Case HffC.6 (Rognlien**); Core power into the SOL = 2.0 MW. Ni-core = 3.0x10^{19} m^{-3}. Peak heat flux to divertor ~ 8 MW/m^2***

- ***Temperature and energy dependent D^+, Li^+ lithium sputtering model (Allain).***

- *Lithium surface temperature: constant temp. model used now, scaled from NSTX estimate for molybdenum surface (Maingi)**. T_s = 350 ° C**. (will need update)*

- *Li^+ sputtered transport model (Brooks) with **MOLDYN computed** (Alain, Alman) lithium reflection and charge state parameters**. Net atom sputtering ~ Y/2, for total yield "Y".***

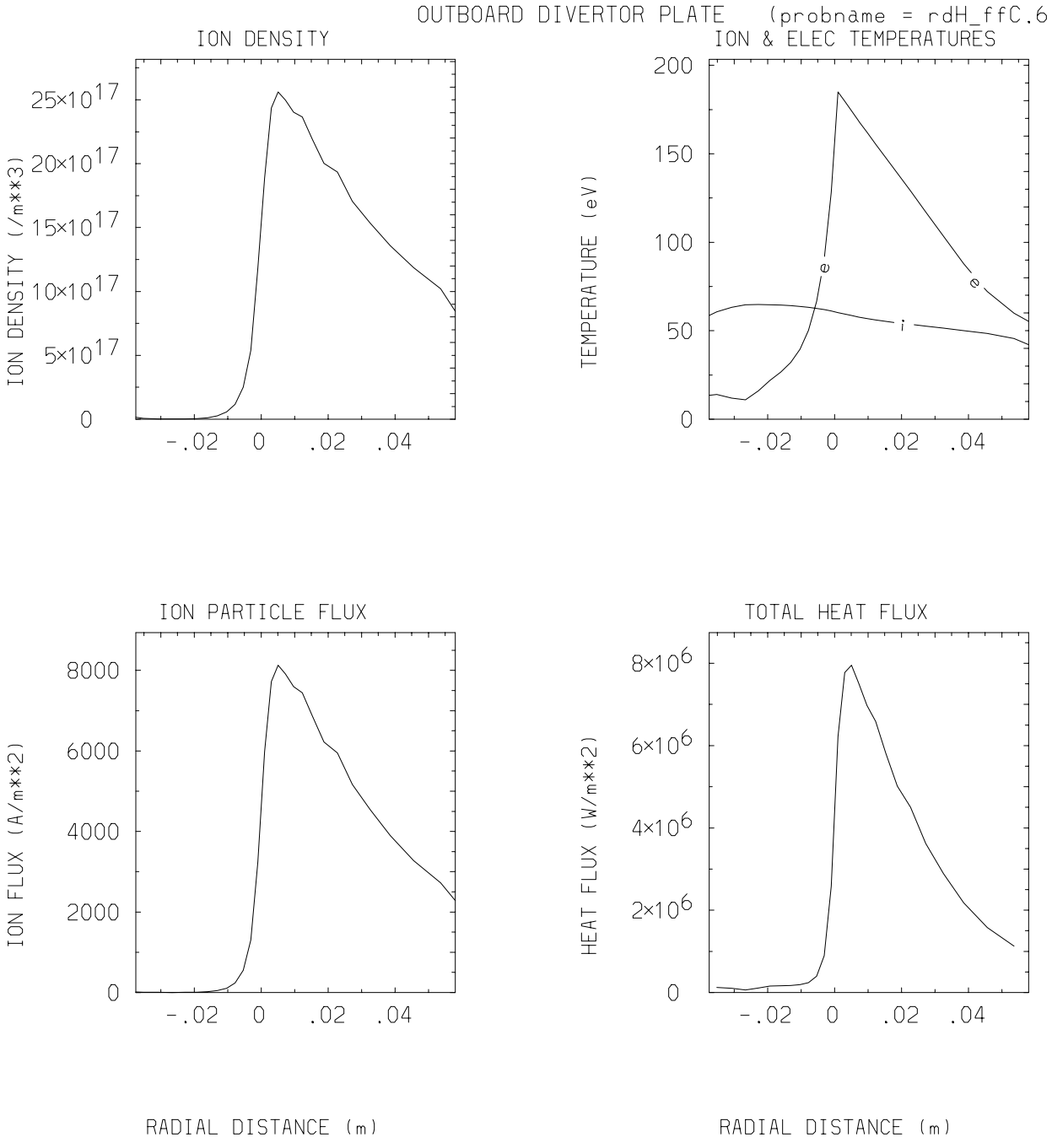
- *Li atoms sputtered self-consistently from entire module surface by D^+ sputtering and self-sputtering.*

- *VFTRIM-3D-verified Thompson random collision cascade sputtered velocity distribution.*

- *ADAS rate coefficients (Evans, Whyte) for electron-impact ionization of Li-I, Li-II, Li-III particles*

- *[100,000 particles launched per simulation]*

UEDGE NSTX SOL PLASMA CASE HffC.6 (Rognlien)



NSTX Lithium Module A Erosion; Key Results

- **Self-sputtering yield peaks at ~ 0.07 (near strike point). Overall self-sputtering is finite (non-runaway).**

- **Overall lithium emission (neutral sputtering + neutral reflection) is high, 17% of D^+ current to divertor.**

- **Sputtering superheat is low, ~ 0.04 MW/m^2 , no runaway problem.**

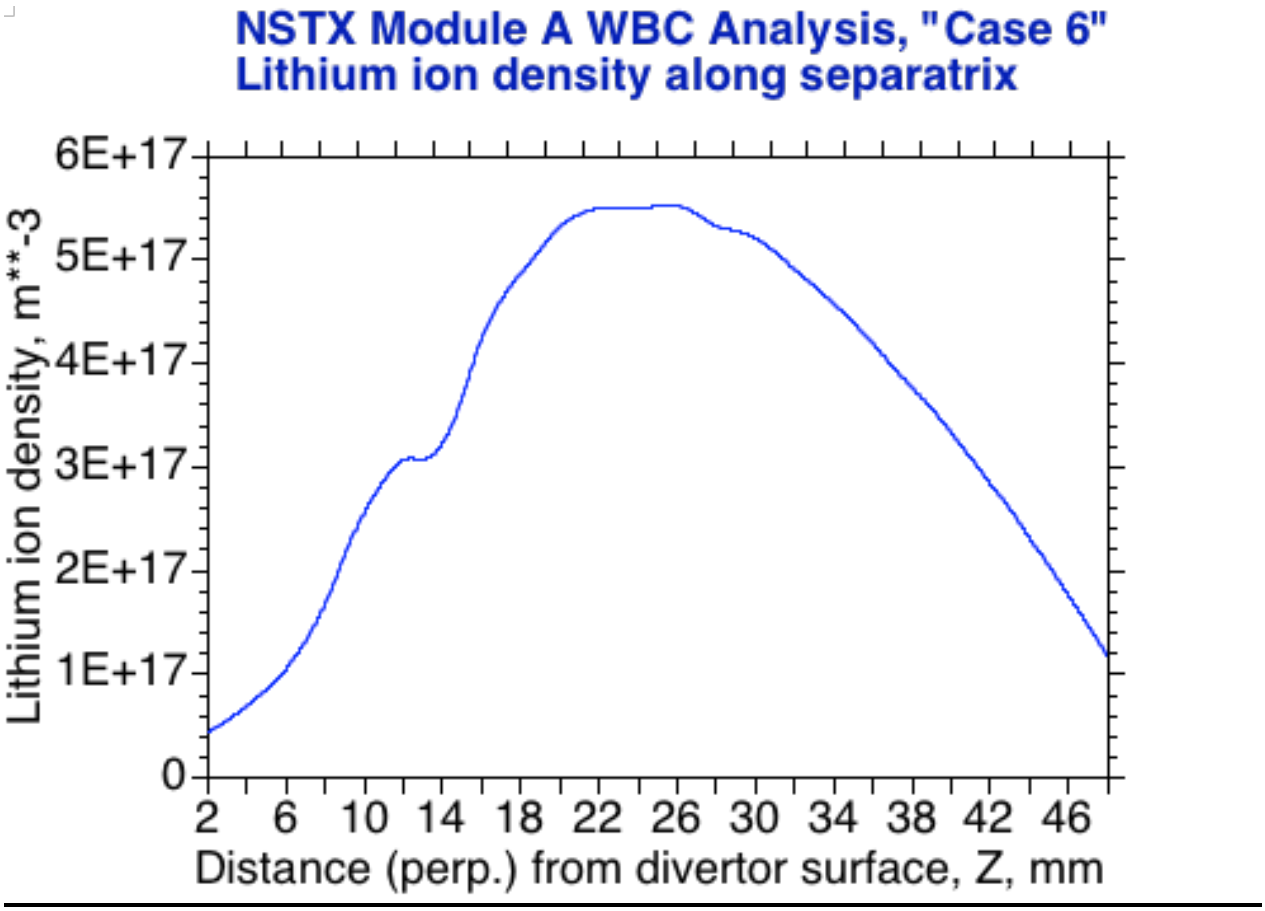
- **Lithium current to SOL/near-surface boundary, ~ 25 % of sputtered current, is high.**

- WBC results for sputtered lithium flux leaving near-surface region furnished as source boundary condition for UEDGE analysis of entire SOL Li transport.

Lithium erosion/redeposition summary
REDEP/WBC NSTX Module-A Analysis (Prelim.)

Parameter	**UEDGE Case HffC.6**
Plasma conditions at strike-point	Te = 185 eV Ne = 1.9x10^{18} m^{-3} Q ~8 MW/m^{2}
Ionization mean-free-path (perp. to surface)	1.8 cm
Charge state*	**1.000**
Angle of incidence* (from normal)	**28 ° (12°)**
Energy*	**295 eV (100 eV)**
Redeposition fraction on module	**0.57**
D^+ sputtering fraction	**0.76**
Self-sputtering fraction	**0.24**
Self-sputtering superheat (peak)	**0.04 MW/m^{2}**
Fraction of sputtered lithium escaping the near-surface region (0-5 cm from plate)	**0.26**
Sputtered lithium atom current from divertor	**2.1 x10^{21} Li/s**
D^+ ion current to divertor	**1.2 x 10^{22} D^+ /s**
Peak Li/D ion density ratio above module	**~ 0.3**

*average value (standard deviation) for redeposited ions



- **Lithium concentration (Li^+/D^+) is high in near surface region**

Next tasks:

- Use actual divertor surface temperature, when available.
- Couple UEDGE results for Li ion flux *towards* surface into WBC.
- Additional UEDGE cases (including lower density, very high edge temp.).
- Update sputter model for static lithium on solid surface with expanded incident energy range.
- Update molecular dynamics results into reflection model.

CONCLUSIONS

- Initial NSTX Module A erosion/redeposition analysis performed. 2 MW core plasma heating yields stable (non-runaway) lithium divertor surface.

- A concern is low shielding ability of near-surface region

- **Near-future work:**
  - **Coupled UEDGE/WBC results**
  - **Updated sputter and temp. models**
  - **NSTX higher power and different density boundary condition cases**