Summary of ISLA-2011 Session V
Lithium Theory / Modeling / Comments

- Theory/Modeling
  1. P. S. Krstic: Dynamics of D retention & sputtering of Li-C-O surfaces
  2. J.N. Brooks : Modeling of plasma/lithium-surface interactions in NSTX: status and key issues
  3. G. Szepes: Turbulent Transport in Lithium Doped Fusion Plasmas
  4. C.S. Chang: Kinetic understanding of Neoclassical Lithium Transport
  5. R.D. Smirnov: Modeling of lithium dust injection and wall conditioning effects on edge plasmas with DUSTT/UEDGE code

- Comments:
  1. M. Ono: Recent progress of NSTX lithium research and opportunities for magnetic fusion research

P. S. Krstic: Dynamics of D retention and sputtering of Li-C-O surfaces

- Goal 1: Develop realistic methods for computational simulation of the Li-C-H, validated by experiments
- Goal 2: Explain specifics of the chemistry of D bonding in Li+carbon
- Charging changes at each simulation step → Quantum-Classical Molecular dynamics required
- Penetration of D and H into C-Li-O easier than into C: ~70% retention of H, D
  - Large percentage of impact D (40%) prefer closeness of Li to settle down, much less to O (already bonded to Li)
- Sputtering yield significantly enhanced - Li largest
  - is this impacting present Li experiments on tokamaks?
- Comparisons to Purdue data from NSTX, lab ongoing
- Next (2011): Li-C-H-O–Mo-He, H-Cumulative interactions, W-Be-C-H-He

J.N. Brooks : Modeling of plasma/lithium-surface interactions in NSTX: status and key issues

- Liquid Lithium Divertor (LLD) plasma/surface interaction analysis
  - Static liquid lithium response, low-D recycle plasma
  - Large sputtered atom ionization MFP (~10 cm), Large Li^{+1} gyroradius (~5 mm), $\Rightarrow$ Kinetic, sub-gyro orbit analysis required (i.e. WBC code)
  - Results:
    - Moderate Li sputtering; no runaway
    - Acceptable Li contamination: ~7% SOL, ~1% Core
    - Carbon (2%) flux to LLD appears acceptable
- Lithium Inner Divertor (HIBD)
  - Static (pure) liquid Li or solid Li surface, high D-recycle plasma
  - Results:
    - A Mo surface may be substantially changed, in 1 second, by C and Li impingement
    - Mo core plasma contamination by sputtering appears low (<0.01%)

G. Szepesi: Turbulent Transport in Lithium Doped Fusion Plasmas

- Microstability analysis with GKW
- Summary of linear simulations – presence of impurity ions…
  - gives rise to impurity-TG driven modes (depending on collisions)
  - stabilizes TEM and ETG modes (Reshko, Roach, PPCF 2008),
  - decouples ion and electron density fluctuations allowing different phase shifts compared to the potential fluctuation
  - drives inward flux of main species via ITG modes while impurity ions are being transported outward

- Both linear and non-linear simulations based on an FTU LLL discharge confirm that: presence of impurities can lead to inward turbulent flux of the main plasma species

C.S. Chang: Kinetic understanding of Neoclassical Lithium Transport

- Described code capabilities of, and predictions from XGC0: Kinetic transport modeling code
- X-point major radius dependence of ExB shearing rate, possibly affecting PLH, was predicted from XGC0 several years ago – consistent with NSTX L-H transition data
- XGC0 predicts at nC/ne=10%, Li moves outward, C+6 moves inward
- With 5% nC/ne, predict Li moves inward much slower speed than C
- Trends qualitatively similar to NSTX impurity ion evolution – i.e. little Li in plasma at end of pulse (when C concentration is highest)
- Many of the Li trends, influence on plasma in the H-mode, as seen in NSTX, could be related to kinetic neoclassical physics

R.D. Smirnov: Modeling of Li dust injection and wall conditioning effects on edge plasmas with DUSTT/UEDGE code

- The coupled DUSTT - UEDGE codes allow self-consistent modeling of dust transport and impact on the edge plasmas
- Validation of the coupled DUSTT/UEDGE code has been performed using 3D reconstructed dust trajectories measured on NSTX
- Dust injection with rates ~ several 10mg/s in modern tokamaks can significantly affects edge plasma parameters, transport and stability
  - The peak power load to the outer divertor plate is significantly reduced
    - Broader heat load profile compared to gas injection
  - Complete plasma detachment in the inner divertor at 60mg/s Li injection rate
  - Radial plasma pressure gradients reduced up to ~40% reduced in the edge
  - Peeling/ballooning stability of the edge plasma possibly improved, suppressing anomalous transport and ELM formation

M. Ono: Recent progress of NSTX lithium research and opportunities for magnetic fusion research

- NSTX testing applications of Li in diverted tokamak configuration
- Potential importance for fusion energy development summarized:
  - Electron energy confinement increased for improved plasma performance
  - Improved electron thermal confinement at edge
  - Reduction in H-mode power threshold
  - ELM stabilization through edge electron p profile modification
  - Lower edge density + impurity control benefits RF heating and non-inductive tokamak start-up
  - Low lithium core dilution demonstrated, enhancing lithium utilization for the challenging divertor solutions
  - Improved NSTX operational efficiency
  - Issues: Narrow divertor heat flux width, impurity accumulation
- **For NSTX Upgrade, what is best Li-based divertor, FW?**
  - Open vs. closed, CPS, LIMIT, slow/fast jets/flow?