Simulations of NSTX with a Liquid Lithium Divertor Module [1]

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The Liquid Lithium Divertor (LLD) module planned for installation in the NSTX lower divertor will provide a nearly toroidally continuous liquid lithium surface in contact with the plasma. The objective is to pump enough deuterium to allow full density control, thereby permitting quasi-steady, high performance H-modes with an increased non-inductively driven current fraction. This paper extends previous simulations [1] of a pre-conceptual LLD design, using improved models and data.

First, transport coefficients in the 2-D edge plasma transport code UEDGE are calibrated against an existing NSTX shot using midplane and divertor diagnostic data. The LLD is then incorporated into the simulations as a reduction in the D recycling coefficient over a section of the divertor. Its location and width are varied, giving the change in core plasma density caused by the pumping action of the lithium surface. These findings are used to corroborate results from an analogous 0-D particle balance model that can be efficiently applied to a wide variety of NSTX plasma configurations, as is needed for optimizing the configuration of the LLD.

The plasma heat flux to the lithium surface computed by UEDGE is input into a 3-D heat transport calculation to determine the temperature profile of the lithium with various substrates. The resulting reflection, sputtering, and evaporation of lithium under these conditions are estimated using updated (since [2]) surface models based on coupled REDEP/WBC, TRIM-SP and molecular dynamics simulations that have been validated against experimental measurements. A self-consistent erosion / redeposition simulation is then performed to determine the net flow of lithium away from the surface. Finally, this flux is input back to UEDGE to predict the distribution of lithium throughout the scrape-off layer and core plasmas.

[1] J. N. Brooks et al., J. Nucl. Mater. 337–339 (2005) 1053.
[2] J. P. Allain et al., J. Nucl. Mater. 337–339 (2005) 94.

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