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Recent Advances towards a Lithium Vapor Box Divertor

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We report here advances from earlier work [1] on a lithium vapor box divertor, in which a lithium vapor cloud is held in place by local evaporation and strong differential pumping, forming a target to dissipate the heat flux from the divertor. The lowest, hottest box contains lithium vapor with nl calculated to extinguish the expected heat flux. Its bottom is wetted with a layer of lithium to handle transient heat fluxes. The upper boxes are much cooler than the bottom box, so lithium is condensed there, and recirculated, greatly limiting the lithium efflux to the plasma.

In recent work we have used Navier-Stokes calculations to confirm the estimates in [1] of the strong differential pumping capabilities of such systems. We have found, however, that reflecting surfaces must be included to induce standing shocks to slow the flow. The approximate condition for this is easily obtained if the reflecting surfaces are at the local stagnation temperature of the vapor.

We have also developed a simplified model for system design that assumes all dissipation occurs in the bottom box, and that E_dis of energy (in eV) is dissipated for each lithium atom entering the divertor plasma from the vapor target, by Langmuir flux. For example, for a fusion power plant dissipating P_dis = 200 MW in its outer divertor leg at R = 6m, a bottom box length l = 0.5m, and a conservative 10 eV per atom energy dissipation, the box temperature is 725 C, the vapor density in the box is 8 10^21 m−3, and the mass efflux, M_dot , through a slit of width d = 0.1m is 228 g/sec. Differential pumping, as shown in figure 1, should reduce the resulting efflux to the plasma to < 1 g/sec.

A small-scale similarity experiment is being designed to validate the Navier-Stokes calculations. It will match Knudsen number and use steam as the similarity fluid, employing thermocouples, pressure sensors and Schlieren imaging to study n_vap, T_vap, flows and shocks.

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[1] R.J. Goldston et al., Physica Scripta, The Lithium Vapor Box Divertor, accepted for publication

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