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Analyses and Experiments Towards a Lithium Vapor Box Divertor

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The divertor for a practical fusion power producing facility very likely must dissipate the intense heat flux emerging from the plasma core volumetrically, rather than allowing it to strike a material surface directly. We have proposed [1, 2] that a dense cloud of lithium vapor be contained in the divertor region by local evaporation from, and condensation onto, capillary porous structures such as 3-D printed tungsten surfaces [3]. Modeling has shown [4] that the heat flowing from a fusion-relevant plasma can be dissipated volumetrically by the radiation and ionization associated with encountering lithium vapor. It has been further shown that such a system can be designed to be robust against large variations in heat flux [5]. The very modest flows of lithium required for such a system can be easily pumped across magnetic fields [6]. Indeed capillary pressure alone is sufficient in the presence of flow channel inserts. Experiments are underway, and being developed, to test this concept in a stepwise manner. We are measuring the ability to contain a small cloud of lithium vapor consistent with calculations using the SPARTA direct simulation Monte-Carlo code. In parallel we are preparing the physics design of an experiment to test volumetric dissipation of a plasma beam on the Magnum-PSI facility [7] in such a localized lithium cloud. We are also preparing the pre-conceptual design of a lithium vapor box option for the divertor in EAST [8], and are developing plans for testing a full toroidal system at very high power density on the NSTX-U experiment. Such as system could also be tested in COMPASS-U and DTT.

[1] R. J. Goldston et al., Physica Scripta T167 (2016) 104017
[2] R. J. Goldston et al., Nuclear Materials and Energy 12 (2017) 1118
[3] P. Rindt et al., Nuclear Fusion 59 (2019) 054001
[4] T. D. Rognlien et al., Nuclear Materials and Energy 18 (2019) 233
[5] E. D. Emdee et al., Nuclear Materials and Energy 19 (2019) 244
[6] E. D. Emdee et al., accepted for publication in Nuclear Fusion
[7] J. A. Schwatz et al., Nuclear Materials and Energy 18 (2019) 350
[8] E. D. Emdee et al., European Physical Society, Division of Plasma Physics, 2019

Country or International Organization

United States of America

Primary authors: Prof. GOLDSTON, Robert (Princeton University); Mr EMDEE, Eric (Princeton University); Mr SCHWARTZ, Jacob (Princeton University)

Presenter: Prof. GOLDSTON, Robert (Princeton University)

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