Liquid lithium as a plasma facing material to drive a path to a viable fusion power plant

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To truly achieve a steady state working fusion power plant there is one major hurdle that needs to be overcome, plasma material interactions (PMI). The materials we use to build these devices is extremely important. Research has shown traditional solid materials (tungsten, molybdenum, carbon, etc.) encounter several issues when exposed to the high heat fluxes in a fusion reactor's divertor region which can reach over 40 MWm^{-2} or more in some cases [1]. Interactions with energetic ions, neutrals and neutrons can cause surface morphology changes (DPA, transmutation, fuzz, bubbles, blisters), ejection of material into the plasma, recycling of cold neutral gas back into the plasma and fuel depletion through implantation into the material [2]. Liquid metals, and in particular liquid lithium (Li), pose several solutions to many of the issues solid materials face [3]. As a liquid it's self-healing and can possibly handle the large heat fluxes seen in the divertor. Its chemical reactivity means that it will essentially trap impurities, unused fuel ions, and neutrals that come out of the plasma. Li reduces the recycling rate of the wall and thus can increase the performance of plasmas [4]. More importantly, recent results indicate that Li can also be a way to remove helium (He) ash effectively from a reactor with up to an 85% reduction in recycled He [5,6]. This means that potentially the way divertors and PFCs are designed in the future could be very different. There are still technological challenges using liquid Li, and these are all under investigation. This talk will focus on PMI challenges and how Li can solve many of these issues as well as the challenges faced by using liquid Li systems. It will focus on the research being conducted at the University of Illinois and the plasma, fusion PMI program at the Center for Plasma Material Interactions [5-7].

[1] J. H. You, *et al.*, J. Nucl. Mater. **544** (2021) 152670.

[2] M. J. Baldwin, *et al.*, Nucl. Fusion **48** (2008) 035001

[3] A. De Castro, *et al.*, Phys. Plasmas, **28**, (2021), 050901.

[4] R. Maingi, *et al.*, Nucl. Fusion, 52 (2012) 083001.

[5] D. Andruczyk, *et al.*, Plasma Phys. Control. Fusion **64** (2022) 085011.

[6] A. Shone, *et al.*, Journal of Fusion, 42:43, (2023).

[7] D. Andruczyk, *et al.*, Fusion Sci. Technol. **79**(8) (2023) 1099.