Macroscopic Motion of Liquid Metal Plasma Facing Components in a Diverted Plasma*

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Liquid metal plasma facing components (PFCs) have been identified as an alternative material for fusion plasma experiments[1]. The use of a liquid conductor where significant magnetic fields are present is considered risky, with the possibility of macroscopic fluid motion and possible ejection into the plasma core. The present work reports on fluid motions that may result in a diverted plasma. As the Liquid Lithium Divertor (LLD) is the first large-scale deployment of a liquid metal PFC in a large machine, the present work calculates expected motions based on the geometry found in the National Spherical Torus Experiment (NSTX).

Analysis is carried out on thermocapillary and thermoelectric magnetohydrodynamic forces caused by temperature gradients in the liquid-container system itself. Capillary effects at the liquid-container interface will be examined which govern droplet ejection criteria. Stability of the interface is determined using linear stability methods. In addition to thermal effects in the liquid-container system, plasma effects will also be considered. Primary among the plasma-material interactions are net currents due to thermoelectric scrape-off-layer effects as well as eddy currents developed during disruptions[2].

Three possibilities are considered crucial in the analysis: ejection of material from the wetted surfaces, de-wetting of container surfaces and the generation of bulk flow tangential to the surface. The first is crucial in avoiding significant perturbations of the core plasma or in the case of a high-Z liquid metal PFCs, radiative collapse of the plasma. The second is important in maintaining the desired liquid metal PFC in contact with the plasma and avoiding the introduction of impurities from the substrate material. The third is important for the generation of passively pumped divertor schemes and liquid metal inventory control.

In addition to the immediate application to the LLD and other liquid metal PFCs, thin film liquid metal effects have application to current and future devices where off-normal events may liquefy portions of the first wall and other plasma facing components.

[1] "Priorities, Gaps and Opportunities: Towards a Long-Range Strategic Plan for Magnetic Fusion Energy", Report to Fusion Energy Sciences Advisory Committee, October 2007.

[2] S.P. Gerhardt, *et al.* Nuclear Fusion **49** (2009) 025005.

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