MEMOS 3D modelling of ELM-induced transient melt damage on an inclined tungsten surface in the ASDEX Upgrade outer divertor

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Recent matched experiments in JET and ASDEX Upgrade [1,2] have exposed small tungsten (W) samples at the outer divertor strike point to high power H-mode plasmas, with Edge Localized Mode (ELM) energy densities and timescales similar to those expected during mitigated ELMs in ITER burning plasmas. Two different sample geometries were deployed in both devices, featuring an abrupt leading edge of ~1 mm height and an inclined surface with (slope angle 15°) such that, in each case, ELM-induced melting could be obtained on the inertially cooled surfaces. Good agreement with the ASDEX Upgrade leading edge experiment (post-mortem melt profiles, net electrical current to the W sample) has been obtained with the MEMOS-3D melt motion code under the conjecture that the current responsible for the **J**x**B** force on the melt layer is the electron flow through the bulk of the sample to replace the loss at the surface due to thermionic electron (TE) emission. The code has been recently updated with respect to the thermophysical W properties & the description of thermionic electron emission under space-charge limited conditions as well as a replacement current module has been added.

Application of MEMOS-3D has now begun for the sloped sample, the geometry of which provides a further important test for the replacement current hypothesis in that incident field line angles are lower in comparison with the perpendicular leading edge so that emitted electrons may escape the melt zone much less readily. The geometry also has the advantage that the loaded surface can be viewed with a fibre-based infra-red (IR) system, allowing direct observation of melt onset [3]. Using spatio-temporal incident heat flux profiles as input and assuming an optical approximation for the power loading, the maximum TE emission current is found following a scaling relation to the plasma flux obtained by dedicated PIC simulations [4]. As a consequence of the combined effects of the sheath virtual cathode and prompt electron re-deposition, the TE current density is already limited at values of surface temperature well below the W melting point and is dramatically reduced with respect to the nominal Richardson current [4]. Once ELM-induced melting is achieved in the simulations, the resulting **J**x**B** force on the melt layer is significantly lower than for the leading edge case, such that the predicted net poloidal melt displacement is on the order of a few mm, roughly consistent with experiment. Moreover, modelled melt velocities, on the order of a few tens of cms^{-1}, are close to those derived from IR images of the actual melt motion [3]. Much more challenging code runs are also underway seeking a qualitative match to the experimentally observed complex final melt profile on the sloped surface and thus understanding of the mechanism(s) leading to the onset and progression of the observed corrugated damage topology.

[1] J. W. Coenen *et al.*, Nucl. Fusion **55** (2015) 023010
[2] K. Krieger *et al*., accepted for publication in Nuclear Fusion
[3] K. Krieger *et al.*, submitted to PSI 2018
[4] M. Komm *et al.*, accepted for publication in Physica Scripta

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