Open Source Performant Multiphysics Driven Design for Fusion Systems

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Fusion pilot plants, irrespective of their plasma confinement regime, have a set of common engineering physics that drive their performance namely ionising radiation, heat transport, continuum and micro mechanics, and in the case of magnetically confined systems also electro-magnetics. These physics combine in different length and time scales to produce a range of emergent phenomena such as melting and sublimation in the case of extreme heat or highly non-linear continuum behaviour where material properties change due to heat and atom-scale displacements under irradation. The complex interplay of these phenomena lead to a number of challenging simulation problems when multiple effects occur in a coupled way often in the limit where we must model the entire history of the component.

We must also address complexity; fusion components are often intricate, composite structures, with multiple materials, cooling channels, ferrous and non-ferrous materials, gaps, vacuum and pressure boundaries to list a small number. How can we model systems that are truly heterogeneous and that become more disordered over time, with significant uncertainty in their models?

This talk will cover a range of efforts within UKAEA in our first endeavours to consider how scalable tools can influence fusion engineering and design. We will compare these with tools from outside of the fusion community, to address a range of these challenges and also speak to outlook as to how these tools will be used.