Multiphysics modelling of the ARC Breeding Blanket – Part I: neutronics

Introduction

The ARC reactor is a proposed concept of high-field fusion reactor under investigation at MIT [1]. Its Breeding Blanket (BB) will be based on a non-conventional approach, as it will have a liquid immersion BB made of molten salt (FLiBe with 90 % ^{6}Li enrichment), containing the Vacuum Vessel (VV), see Figure 1. The same salt will also be used as coolant for the other components, such as the VV and the divertor. Inside the Blanket tank, the neutrons coming from the fusion reactions taking place in the plasma will interact with the lithium in the salt to produce tritium.

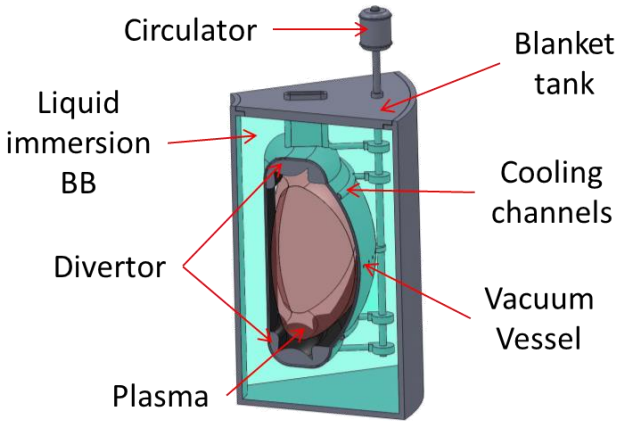

Figure 1: Conceptual scheme of the ARC blanket tank containing the liquid BB, the VV and the divertor.

The modelling of such a complex system requires the analysis of different physical phenomena, such as the effect of the magnetic field on the fluid flow (MHD), the propagation of neutrons in the salt and the natural convection due to the power generation inside the salt caused by nuclear reactions.

Aim of the work

The aim of the present proposal is to develop a neutronic model of the ARC molten salt BB and to couple it to the other models needed, i.e. a 3D CFD/MHD model of the blanket tank developed with the OpenFOAM code [2], and a 1D system-level MHD model developed with the Modelica language [3]. The model should aim mainly at the estimation of the distribution of the generated power in the blanket tank and of the Tritium Breeding Ratio. In addition, since Li is not a material typically used in fission systems, it is expected that the uncertainty on nuclear data might be relevant, thus an uncertainty quantification step could be necessary.

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References

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[2] H. G. Weller, G. Tabor, C. Fureby, and H. Jasak, "A tensorial approach to computational continuum mechanics using object-oriented techniques," Computers in Physics 12(6):620–631, 1998.

[3] Modelica Association, “Modelica® - A Unified Object-Oriented Language for Systems Modeling - Language Specification Version 3.4,” 2017.