On simulation of multi-physics fusion phenomena with Alya, a multipurpose High Performance Computing software

P. Bonilla[1], J. Lorenzo[1], O. Ortega[1], A. Soba[2,3], H. Calmet[1], O. Fernández[1], E. Goldberg[1], S. Gómez[1], X. Granados[4], G. Houzeaux[1], O. Lehmkuhl[1], M. Mantsinen[1,5], J. Manyer[1], P. Pastells[1], X. Sáez[1]

[1] *Barcelona Supercomputing Center (BSC), Barcelona, Spain*
[2] *National Atomic Energy Commission, Argentina (CNEA), Buenos Aires, Argentina*
[3] *National Scientific and Technical Research Council (CONICET), Buenos Aires, Argentina*
[4] *Institute of Materials Science of Barcelona (ICMAB), Barcelona, Spain*
[5] *Catalan Institution for Research and Advanced Studies (ICREA), Barcelona, Spain*

Fusion nuclear reactors are highly complex systems from a multi-physics and modelling perspective. The simulation of interdependent physics phenomena requires involved numerical models and costly computations in several time and space scales. Integration of these multi-physics models is key to understand how the different physics processes affect each other. Furthermore, only optimal efficiency of these coupled physic models enables whole domain simulations to validate the models and integrate them in the community tools. In this work we present nuclear fusion applications based on Alya computational mechanics multi-physics HPC software [1]. Alya's main advantages are its supercomputing resource optimisation and its in-built modular multi-physics implementation that overcomes the necessity of data converters which can significantly hamper a multi-physics simulation. This paper highlights the current state of the development of the main Alya modules applied to fusion, i.e. those of magnetism, hydraulics, thermodynamics and neutron transport, designed to allow future coupling.

Regarding test cases for validation of the modules, first the magnetism module developed to predict the performance of High Temperature Superconductors (HTS) cables in fusion magnets is compared against analytical models and numerical benchmarks in the literature. Then, the advances in the neutron transport module are validated against benchmarks from SINBAD, a Nuclear Energy Agency database in which tests for simple geometries are developed [2]. Finally, the hydraulics and thermodynamics modules are tested on a simulation of the heat dissipation on ITER's first wall with a given source term to account for the nuclear deposition.

References

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