An introduction to modern nuclear reactor simulators
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Abstract:

A nuclear reactor simulator is a collection of computer codes regrouped under a common system environment to predict the physical behaviour of the reactor for design and safety purposes. This behaviour is governed by many concurring physical phenomena describing the production of thermal energy by nuclear fission (neutronics), the removal of heat by the coolant (thermal-hydraulics and heat transfer), the mechanical deformations and the change of material properties under irradiation (mechanics and material science). Furthermore, these disciplines interact non-linearly with very different time scales.

After an opening overview of the multi-physics problems encountered in reactor physics and analysis, the main techniques for their solutions will be briefly outlined. The common features of the most popular reactor concepts are then recalled to motivate the hierarchical construction of the modelling geometry, with the underlying approximations for local heterogeneities. Next, the transition in history from the legacy codes up to the modern nodal simulators, largely used nowadays in industry, is reviewed. The nuclear data preparation is explained together with the paradigm of homogenization and equivalence in coarse meshes. The main limitations of the current approach are also discussed, in order to pave the way for future trends and perspectives with micro-scale modelling on the new object-oriented platform for multi-physics calculations. At the end, an illustration of a standard lattice problem coupling neutronics and thermal-hydraulics, based on a simplified closed channel description, will be given.

Bio:

Daniele Tomatis is a Research Engineer at the French Alternative Energies and Atomic Energy Commission (CEA), France. He achieved his master degree in Nuclear Engineering and Energetics (2006) and his PhD (2010) at the Politecnico di Torino, Italy. After several years at AREVA (now Framatome) as lead developer of nuclear computer codes, he joined the Service for Reactor Studies and Applied Mathematics (SERMA) at the Saclay site of CEA in 2015. His current activities concern the design and safety of the French PWR reactors, with particular emphasis in the new EPR units.