PhD offer

Titre : Decay heat uncertainty calculations with associated sensitivity studies. Impact of nuclear data.

Group : Nuclear structure and Energy

Tutor:

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Context and objectives:

The determination of decay heat is a major safety issue for a reactor in operation but also for the transport of burnt fuel and nuclear waste management. It is in particular a key parameter for the design of the Generation IV safety systems but also for the use of innovating fuels. The calculation of decay heat relies on the combination of reactor simulations to estimate the fuel inventory and on nuclear data : decay properties of the fission products and actinides, fission yields and cross sections.

The uncertainty assessment of decay heat calculations is a topic of interest for the nuclear industry on the current fuel cycle but also for the Gen IV reactors and the R&D associated to their designs and safety studies. The Nuclear Structure and Energy group of the SUBATECH laboratory performs decay heat calculations with the Monte Carlo depletion code SERPENT 2 for fission pulses, fuel assemblies but also reactor cores. The group is also involved in new decay measurements of fission products which have decay schemes biased by the Pandemonium effect. The Pandemonium effect arises from the low efficiency at high energy of Germanium detectors. This has direct consequences on decay heat calculations with an over-estimation of the β^- contribution and a under-estimation of the γ contribution. The experimental technique used for these new measurements is the TAS method (Total Absorption Spectroscopy), which allows to have an excellent detection efficiency even at high energy. The aim for decay heat calculations is now to improve the uncertainty associated to it and especially the impact of nuclear data by using simultaneously approaches based on the Total-Monte Carlo method (TMC) and the perturbation theory.

Subject:

A first study will be focussed on thermal/fast fission pulses ($^{235,233}U$ and $^{239,241}Pu$). The sensitivity coefficients of decay heat to the following nuclear data: fission yields, half-life, branching ratio and mean decay energies will be estimated using the perturbation theory. The needed tools to automatize the TMC method coupled to the SERPENT code will also be developped and used to determine the uncertainty associated to nuclear data for decay heat. A collaboration with the Paul Scherrer Institute in Switzerland is foreseen. For the fission yields, the GEF code and the experimental covariances matrices measured by the CEA will be used. In addition, uncertainty calculations for PWR assemblies decay heat (UO_2, MOX) and also some comparison with existing data at different burnups and cooling times will be performed.

The second part of the PhD will be focussed on the impact of the nuclear data on decay heat calculations for Gen IV reactors, especially fission yields and mean decay energies. The first case studied will be the Molten Salt Reactor with Fast neutron spectrum (MSFR) for Th/U and U/Pu fuel cycles which is a Gen IV reference concept initiated by the LPSC laboratory in Grenoble. The S.E.N team contributes in decay heat calculations for the core part, emergency draining system and fuel treatment unit. In addition, some work will be dedicated to determine the final list of key fission products for some Gen IV concepts which are Pandemonium candidates and need to be re-measured with the TAS technique, aiming also to improve the nuclear decay data librairies.