Neutronics, burnup and nuclear fuel (NEPAL15)

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Project objectives, effect on safety

NEPAL15 = direct one-year extension of NEPAL (SAFIR2014)

Methods development of computer codes

1. Accurate burnup calculations
2. Mesoscopic modeling of nuclear fuel
3. Coupling of fuel temperature profile to neutronics
4. Processing of cross section libraries for Serpent

Deliverables: new calculation methods → scientific publications + improved codes

Deliverables: new expertise and the new experts themselves (1 DSc, 1 MSc and 2 BSc)
Example 1: Accurate burnup calculations

Monte Carlo burnup calculations combine sequential steady state neutronics and depletion calculations with a coupling scheme. CRAM is a fast and accurate method for depletion calculation that was further developed in NEPAL15. Internal substeps illustrated below.

Note:
Atomic fraction $10^{-30}$ < one atom per cubic meter

CRAM = Chebyshev Rational Approximation Method
Example 2: Mesoscopic fuel model

Fission gas release simulated with creep damage and repair models. Fractional gas release as a function of scaled time is shown in a. Snapshots of gas concentration b-c-e-f: gas is released through the top boundary. The corresponding y-directional concentration profiles are plotted in d. Here the damage repair rate is sufficiently high to limit gas release to the top part of the system.

Percolation theory
Gas nodes
Interconnecting bonds
Microcracks, porosity
Pore pathways