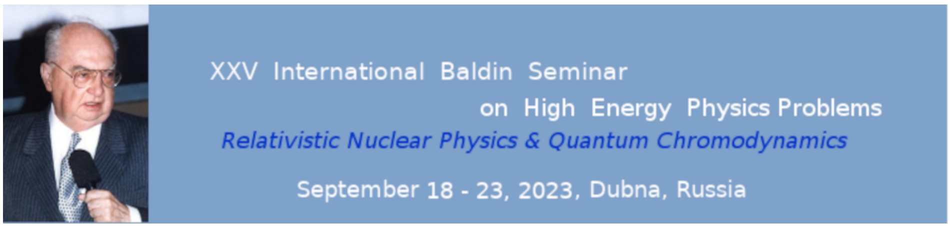

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Energy Production in Subcritical Fission Reactors

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A synthesis of the research developed in the frame of E&T collaboration, aimed to identify the conditions which maximize the efficiency of an accelerator driven subcritical reactor (ADSR) are presented. Experiments performed in the extended U target "Quinta"irradiated with deuteron and 12C beams with energies 0.5-4 AGeV and simulations realized with the toolkit Geant4 in enriched targets were meant to find on one hand, the optimal beam and energy for ADSR, and on the other hand, the core characteristics that maximize the energy gain G (defined as the ratio of the electrical power produced to the electrical power spent for the plant functioning) and the actinides incineration [1-3].
The information about particle fluence, fission distribution and energy released is obtained from simulations realized with the toolkit GEANT4. The electromagnetic interaction was modeled with standard electromagnetic models. For the inelastic interaction of hadrons intranuclear cascade models were used (Bertini cascade for barions and mesons, binary cascade for ions). In the case of neutrons with energy below 20 MeV the interactions were modeled with the high precision neutron package based on a detailed implementation of the experimental data from ENDF library.
The isotopes evolution was calculated using the spectra registered through simulation to calculate the cross sections for the reactions which contribute to the isotopes accumulation rates and our program written in the frame of toolkit ROOT for solving the system of coupled differential equations through the exponential matrix method. The power produced was obtained from the simulation and for the power spent a method to calculate it by scaling from the data about the accelerator efficiency for a reference particle was used.
Aspects related with the core geometry, the optimal value of the criticality coefficient keff, the material used for the converter, and the enrichment were analyzed. A core with keff 0.985-0.988, Be converter and low enrichment ensure deep actinides burning during a cycle (20-25 % from the initial actinides mass, in comparison with 6-7 % realized in a fast reactor). The optimal proton energy is in the range 1-1.5 GeV, depending on the accelerator type (linear accelerator or cyclotron) with G values 12-14. Ion beams starting with 7Li realize significantly higher G, from 20-25 for 0.25 AGeV 7Li to 35-45 for 16O and 20Ne with energy 0.75-1 AGeV.
The influence of the fuel type on the ADSR performance was also, analyzed. Metallic, oxide and nitride fuels with various enrichment distributions were taken into account. The use of nitride fuel is preferable in ADSR because allows to accommodate high power densities.
The most attractive for ADSR is a beam of 7Li with energy 0.25 AGeV. It produces the same net power as 1.5 GeV protons, but necessitates an accelerator 2.6 times shorter, with a reduction of the costs for building and maintenance.
The comparison with the values of the energy gain predicted in fusion power plants (~3 in the case of magnetic plasma confinement [4], ~4 in the case of inertial confinement [5]) demonstrates that ADSR can be a more efficient source of energy.

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