ID de Contribution: **8** Type: **Non spécifié**

Towards improvement of the 238U level scheme using gamma-spectroscopy of the (n, n'gamma) reaction

jeudi 18 janvier 2024 13:40 (25 minutes)

Improving the knowledge of the neutron population of actual and future reactors is required to improve the accuracy of neutronics simulations. Among others, this population is driven by (n, xn) reactions, including inelastic scattering, these reactions changing the number of neutrons in a reactor core and their speed. Their cross sections are however, still nowadays, not precisely known. That is why the neutron inelastic scattering cross section of ^{238}U, main nucleus of a nuclear reactor cores fuel, features in the High Priority Request List [1].
The prompt γ-ray spectroscopy coupled to time-of-flight measurements is one method to measure the (n, xn') cross section. The total (n, xn') cross sections can be inferred from the measured (n,xnγ) cross sections and the level scheme information [2]. However, the ^{238}U level scheme knowledge is still very incomplete: the discrete states are assumed to be fully known up to 1.3 MeV only [3] and the average uncertainties on branching ratios in ENSDF [4] are of 8%. Moreover, sensitivity calculations performed with the TALYS code [5] showed that modifying the branching ratios of 10% in the input's code can have an impact of up to 4% on (n, n'γ) cross sections [2].
It has therefore become of high importance to improve the level scheme knowledge. An initiative to experimentally reinvestigate the ^{238}U nucleus structure has been launched with the γ-γ coincidences method thanks to the coupling between the ν-Ball γ-spectrometer [6] and the LICORNE neutron source [7, 8] of the ALTO facility. Indeed, the LICORNE source allows the production of a pulsed quasi-mono-energetic kinematically focused neutron flux thanks to the p(^{7}Li, n)^{7}Be inverse reaction, the produced ^{7}Li beam impinging on a ^{1}H-gas cell. The neutron flux impinged then on the ^{238}U target. The γ produced have been collected by the ν-Ball γ-spectrometer thanks to the two rings of 12 HPGE-Clover detectors composing it.
Two ν-Ball campaigns have been led in 2018 and 2022. The analysis of the γ-γ coincidences matrix obtained during the first ν-Ball campaign with a neutron flux of a mean energy of 2.1 MeV has been performed thanks to the Radware software [9]. The data obtained during the second ν-Ball campaigns, with a much higher statistics and much clearer, are now used to double-check the obtained level scheme. In total, 91 γ and 51 levels registered in ENSDF have been confirmed and 125 new γ and 51 new levels have been found.

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Classification de Session: Session 5