Investigation of the structure of $^{235}U(n_{th},fission)$ prompt gamma energy spectrum by FIFRELIN

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Abstract: The gamma-ray spectrum up to 20 MeV of the $^{235}U(n_{th},fission)$ reaction is calculated by FIFRELIN, the fission event generator based on phenomenological reaction models, and nuclear structure data. Comparisons are made with a measurement performed at the Institut Laue Langevin (ILL) to verify the accuracy of FIFRELIN and study the mechanisms responsible for high-energy gamma-ray emission.
The spectra featured by a bump at 4 MeV, a shoulder from 6 to 8 MeV, and a hump around 14 MeV agree well whereas the spectrum of FIFRELIN is lower than that of the measurement in the gamma energy range from 8 MeV to 13 MeV. FIFRELIN shows that the bump around 4 MeV is attributed to the deexcitation of ^{132}Sn which does not have excited states below 4 MeV owing to it closed shells. The shoulder from 6 to 8 MeV is explained by the neutron separation energy of fission fragments from 6 to 8 MeV. The fragments with excitation energy lower than the neutron separation energy emit gamma-rays whereas those with higher excitation energies favor neutron emission. The gamma-ray spectrum consequently drops in this energy range.
The hump at 14 MeV is attributed to the first gamma de-excitation of light fission fragments to the states close to the ground state. Heavy fission fragments, whose mean excitation energy before neutron emission is about 9 MeV according to FIFRELIN, scarcely contributes to this hump. In contrast, the mean of excitation energy of light fission fragments are 14 MeV. Their transitions to low-energy states are responsible for the gamma-rays of the hump. Owing to this mechanism, the height of the hump depends on the level density model. The hump simulated using the Composite Gilbert-Cameron Model was lower than that using Hartree-Fock-Bogoliubov model, which can take into account for the nucleus-specific characteristics in a more sophisticated manner.
This study illustrated that FIFRELIN is robust tool which can reproduce and identify the origins of the features characterizing the gamma-ray spectrum up to 20 MeV of ^{235}U thermal fission.