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Hauser-Feshbach Statistical Decay and Beta Decay Calculation for Primary Fission Fragments

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We develop a Hauser-Feshbach Fission Fragment Decay model code, HF^{3}D and demonstrate its application to more than 1,000 primary fission fragments formed in the low-energy neutron-induced fission of ^{235}U. The HF^{3}D code allows us to calculate the de-excitation of highly excited primary fission fragment by emitting prompt neutrons and γ rays, and the sequential β decay. The model calculation is extended to higher incident neutron energies up to the second chance fission threshold.

In the past, fission product yield (FPY) data evaluations relied on some models such as the Z_p model by Wahl [1] and isomeric ratios by Madland and England [2] to provide a complete set of FPY. There still remains a need for developing a more sophisticated method to improve the quality of FPY data. The Monte Carlo simulation is the most widely used technique to obtain stochastically distributed fission observables such as FPY. However, the Monte Carlo technique is sometimes time-consuming especially when it samples the fission fragment with very small probability in the tails of the yields.

Instead of performing the Monte Carlo sampling, we generate the distribution of primary fission fragments $Y_p(Z, A, TKE)$ and integrate over the distributions of yield, spin, parity, and excitation energy in a deterministic way. Two important model parameters that define an initial configuration of a fission fragment; (1) the anisothermal parameter of energy split into two complementary fission fragments and (2) the spin distribution of the populated states, are adjusted to reproduce the experimental data. The HF^{3}D code calculates the neutron multiplicity $\overline{\nu}(A)$, prompt neutron and γ spectra, independent fission product yield $Y_I(Z, A)$, and isomeric ratio. We also demonstrate for the first time the energy dependency of the $Y_I(Z, A)$ and the isomeric ratios. The calculated $Y_I(Z, A)$ is further tested in the β decay chain to obtain the cumulative fission product yield $Y_C(Z, A)$.

We will present and discuss our results calculated with the HF^{3}D model by comparison with available experimental data. This model aims at improving the evaluation of the FPY and isomeric ratios by using the Hauser-Feshbach and β decay treatments for the fission fragment de-excitation process.

[1] A. C. Wahl. Systematics of fission-product yields. Technical Report LA-13928, Los Alamos National Laboratory, 2002.
[2] D.G.MadlandandT.R.England.The influence of isomeric states on independent fission product yields. Nuclear Science and Engineering, 64(4):859–865, 1977.

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