A new parameter set of fission product mass yields systematics

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In this systematics, mass yields curve $\psi(A,E)$ is expressed like Moriyama-Ohnishi systematics as follows:

$$\begin{aligned}\psi(A,E) &= N_s\psi_s(A,E) + N_a\psi_a(A,E)\\ &= N_s\psi_s(A,E) + N_a\left[\psi_{h1}(A,E)+\psi_{l1}(A,E)+F\{\psi_{h2}(A,E)+\psi_{l2}(A,E)\}\right],\end{aligned}$$

where $\psi_s(A,E)$ and $\psi_a(A,E)$ are symmetric and asymmetric components respectively. The asymmetric components are then divided into heavy $\psi_h(A,E)$ and light $\psi_l(A,E)$ components with two curves (1 and 2). Each component is assumed to be Gaussian. Then there are 5 Gaussians in this systematics. The three components, $\psi_s(A,E)$, $\psi_{h1}(A,E)$ and $\psi_{h2}(A,E)$ in the above equation are then expressed as:

$$\begin{aligned}\psi_s(A,E) &= \frac{1}{\sqrt{2\pi}\sigma_s}\exp\left\{-(A-A_s)^2/2\sigma_s^2\right\},\\ \psi_{h1}(A,E) &= \frac{1}{\sqrt{2\pi}\sigma_{h1}}\exp\left\{-(A-A_{h1})^2/2\sigma_{h1}^2\right\},\\ \psi_{h2}(A,E) &= \frac{1}{\sqrt{2\pi}\sigma_{h2}}\exp\left\{-(A-A_{h2})^2/2\sigma_{h2}^2\right\},\end{aligned}$$

and other two functions $\psi_{l1}(A,E)$ and $\psi_{l2}(A,E)$ for the light fragment are given by reflecting $\psi_{h1}(A,E)$ and $\psi_{h2}(A,E)$ about the symmetric axis $A_s=(A_f-\bar{\nu})/2$. Here A_s, A_{h1} and A_{h2} are the mass numbers corresponding to the peak positions of the Gaussian distribution curves, and σ_s^2, σ_{h1}^2 and σ_{h2}^2 are the dispersions of these distributions. A_f denotes the mass number of the fissioning nuclide. The quantity $\bar{\nu}$ is the average number of prompt neutrons emitted per fission. Other N_s, N_a and F are normalization factors and determined by systematics. The normalization factors N_s and N_a are given by:

$$\begin{aligned}N_s &= 200/(1+2R),\\ N_a &= 200R/\{(1+F)(1+2R)\},\end{aligned}$$

where R is the ratio of the asymmetric component to the symmetric component and F the ratio of the asymmetric component 1 to the asymmetric component 2. Then the total yield is normalized to be 200%. As seen in these equations, there are 8 parameters to be determined in this systematics, that is, $\bar{\nu}$, A_{h1}, A_{h2}, σ_s^2, σ_{h1}^2, σ_{h2}^2, R and F.

Following are the expressions of the 8 parameters.

$$\bar{\nu} = 1.404 + 0.1067(A_f-236) + \left[14.986-0.1067(A_f-236)\right]\cdot\left[1.0-\exp(-0.00858E^*)\right],$$

where E^* is the excitation energy ($E^* = E + BN$; E : incident energy; BN : binding energy). This expression of $\overline{\nu}$ is the same as that proposed by Wahl at the 1999 CRP Meeting.

$$R = [112.0 + 41.24\sin(3.675S)] \cdot \frac{1.0}{BN^{0.331} + 0.2067} \cdot \frac{1.0}{E^{0.993} + 0.0951},$$
$$\sigma_s = 12.6,$$
$$\sigma_{h1} = (-25.27 + 0.0345A_f + 0.216Z_f)(0.438 + E + 0.333BN^{0.333})^{0.0864},$$
$$\sigma_{h2} = (-30.73 + 0.0394A_f + 0.285Z_f)(0.438 + E + 0.333BN^{0.333})^{0.0864},$$
$$A_{h1} = 0.5393(A_f - \overline{\nu}) + 0.01542A_f(40.2 - Z_f^2/A_f)^{1/2},$$
$$A_{h2} = 0.5612(A_f - \overline{\nu}) + 0.01910A_f(40.2 - Z_f^2/A_f)^{1/2},$$
$$F = 10.4 - 1.44S.$$

In the above equations, S is the shell energy formula given by Meyer and Swiatecki, which is given by:

$$S(N,Z) = 5.8s(N,Z),$$
$$s(N,Z) = \frac{F(N) + F(Z)}{(\frac{1}{2}A)^{\frac{2}{3}}} - 0.26A^{\frac{1}{3}},$$
$$F(N) = q_i(N - M_{i-1}) - \frac{3}{5}(N^{\frac{5}{3}} - M_{i-1}^{\frac{5}{3}}), \quad \text{for } M_{i-1} < N < M_i ,$$
$$q_i = q(n),$$
$$= \frac{3}{5}\frac{M_i^{\frac{5}{3}} - M_{i-1}^{\frac{5}{3}}}{M_i - M_{i-1}}, \quad \text{for } M_{i-1} < n < M_i ,$$

where M_i are the magic numbers, which are Z = 50, 82, 114 and N = 82, 126, 184. The numbers of $Z = 100$ and $N = 164$ employed in Moriyama-Ohnishi systematics are removed in the present systematics.