A NEW PARAMETER SET OF FISSION PRODUCT MASS YIELDS SYSTEMATICS

J. Katakura
Nuclear Data Center, Department of Nuclear Energy Systems,
Japan Atomic Energy Agency (JAEA)
Tokai-mura, Naka-gun, Ibaraki-ken, 319-1195 Japan

The mass yields curve $\psi(A,E)$ is expressed in a similar manner to the Moriyama-Ohnishi systematics as follows:

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

where $\psi_s(A,E)$ and $\psi_a(A,E)$ are symmetric and asymmetric components, respectively. Asymmetric components are then divided into heavy $\psi_h(A,E)$ and light $\psi_l(A,E)$ components to give two Gaussian curves (1 and 2). Five Gaussians are produced in this systematics. The three components: $\psi_s(A,E)$, $\psi_{h1}(A,E)$ and $\psi_{h2}(A,E)$ in the above equation are expressed as:

$$\psi_s(A,E) = \frac{1}{\sqrt{2\pi}\sigma_s}\exp\left\{-(A-A_s)^2/2\sigma_s^2\right\},$$

$$\psi_{h1}(A,E) = \frac{1}{\sqrt{2\pi}\sigma_{h1}}\exp\left\{-(A-A_{h1})^2/2\sigma_{h1}^2\right\},$$

$$\psi_{h2}(A,E) = \frac{1}{\sqrt{2\pi}\sigma_{h2}}\exp\left\{-(A-A_{h2})^2/2\sigma_{h2}^2\right\},$$

and the 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 $A_s = (A_f - \bar{\nu})/2$. 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, and $\bar{\nu}$ is the average number of prompt neutrons emitted per fission. N_s, N_a and F are normalization factors to be determined by systematics:

$$N_s = 200/(1+2R),$$

$$N_a = 200R/\left\{(1+F)(1+2R)\right\},$$

where R is the ratio of the asymmetric component to the symmetric component, and F is the ratio of asymmetric component 1 to asymmetric component 2. The total yield is normalized to be 200%. There are eight parameters to be determined in this systematics: $\bar{\nu}$, A_{h1}, A_{h2}, σ_s^2, σ_{h1}^2, σ_{h2}^2, R and F.

Expressions for the eight 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 ($E^* = E + BN$ in which E is the incident energy, and BN is the binding energy). This expression for $\bar{\nu}$ is the same as that proposed by Wahl at the IAEA Research Coordination Meeting in 1999.

$$R = \left[112.0 + 41.24 \sin(3.675S)\right] \cdot \frac{1.0}{BN^{0.331} + 0.2067} \cdot \frac{1.0}{E^{0.993} + 0.0951}$$

$$\sigma_s = 12.6,$$

$$\sigma_{h1} = (-25.27 + 0.0345A_f + 0.216Z_f)(0.438 + E + 0.333BN^{0.333})^{0.0864}$$

$$\sigma_{h2} = (-30.73 + 0.0394A_f + 0.285Z_f)(0.438 + E + 0.333BN^{0.333})^{0.0864}$$

$$A_{h1} = 0.5393(A_f - \bar{\nu}) + 0.01542A_f(40.2 - Z_f^2 / A_f)^{1/2}$$

$$A_{h2} = 0.5612(A_f - \bar{\nu}) + 0.01910A_f(40.2 - Z_f^2 / A_f)^{1/2}$$

$$F = 10.4 - 1.44S$$

where S is the shell energy formula given by Meyer and Swiatecki, which is given by the equation:

$$S(N,Z) = 5.8s(N,Z),$$

$$s(N,Z) = \frac{F(N) + F(Z)}{(\frac{1}{2}A)^{\frac{2}{3}}} - 0.26A^{\frac{1}{3}},$$

$$F(N) = q_i(N - M_{i-1}) - \frac{3}{5}(N^{\frac{5}{3}} - M_{i-1}^{\frac{5}{3}}), \quad \text{for } M_{i-1} < N < M_i \,,$$

$$q_i = q(n),$$

$$= \frac{3}{5}\frac{M_i^{\frac{5}{3}} - M_{i-1}^{\frac{5}{3}}}{M_i - M_{i-1}}, \quad \text{for } M_{i-1} < n < M_i \,,$$

M_i are the magic numbers (Z = 50, 82, 114 and N = 82, 126, 184); $Z = 100$ and $N = 164$ employed in Moriyama-Ohnishi systematics have been removed in the present systematics.