Parameterization of the experimental fusion-fission cross sections for Lanthanides

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Introduction

A study of fusion-fission cross sections for Lanthanides is important for their synthesis. Literature survey shows that many experimental fusion fission cross sections are available for different projectile-target combinations at different energies. In the present work, we have made an attempt to parameterize the available experimental fusion fission cross sections of Lanthanides.

Theory

Once the experimental fusion fission cross sections were extracted from different experiments available in the literature [1-14], a search was made for their parameterization. Since it is evident that fusion fission depends on the size of the splitting fragments, the best way is to parameterize them in terms of the radius dependence i.e. in terms of $A^{1/3}$. It is also evident from the literature that fusion fission cross section inversely depends on energy E_{cm}. Fusion fission process also depends on the quantity Z^2/A. By considering these facts, we have constructed a new function (Y) for parameterization of fusion fission cross section. This function depends on the atomic number and mass number of compound nucleus and fission fragments.

$$Y = \left(\frac{r_c^2}{E_{cm}}\right) \times \left(\frac{Z^2}{A}\right) \times \left(\frac{(A_1 A_2)^{1/3}}{A_1^{1/3} + A_2^{1/3}}\right) - \qquad (1)$$

here A, A_1 and A_2 are mass numbers of the compound nucleus and fission fragments respectively. Z and A are atomic number and mass number of compound nuclei.

$$r_c = D_1 + D_2 + 1.44 \qquad (2)$$

Here $D_1 = R_1 - \left(\frac{1}{R_1}\right)$ and $D_2 = R_2 - \left(\frac{1}{R_2}\right)$

where $R_1 = 1.28A_1^{1/3} - 0.76 + 0.8A_1^{-1/3}$ and

$R_2 = 1.28A_2^{1/3} - 0.76 + 0.8A_2^{-1/3}$

Based on the function defined in equation (1) a search was made for parameterization of available experimental fusion fission cross section.

Results and discussion

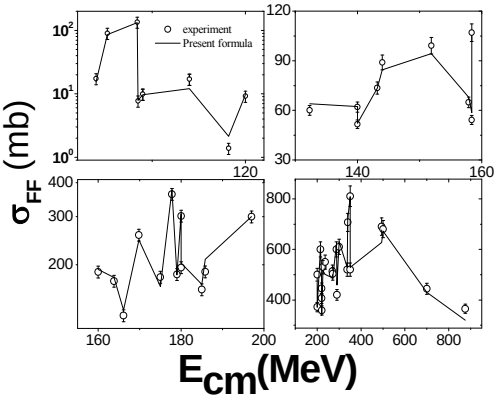
Using the available experimental data, we obtained non linear analytical relations for fusion fission cross sections. Fusion-fission cross section (mb) for different fragment combinations of compound nuclei of atomic number range $57 \le Z \le 71$ is parameterized for different energy ranges are as follows.

$$\sigma = \begin{cases} 8.48903 \times 10^{115}\ Y - 16.5858 & for\ 0 \le E_{cm} \le 100MeV \\ 264.771261 \times Y - 1760717.168 / Y & for\ 100 \le E_{cm} \le 120MeV \\ -144553684.2 / Y + 44.07264 & for\ 120 \le E_{cm} \le 130MeV \\ -14.6822 ln(Y) + 312.6613 & for 130 \le E_{cm} \le 160MeV \\ 33.4363\ ln(Y) - 350.8888 & for\ 160 \le E_{cm} \le 200MeV \\ -6.6555 \times 10^{-5}\ Y & \\ +0.37456\sqrt{Y} + 2.12769 & for\ 200 \le E_{cm} \le 800MeV \end{cases}$$

In the above equation, Y is the function defined in equation (1). This equation valid for

atomic number range 57≤Z≤71 and energy up to 800MeV.

Fig 1: The comparison of fusion fission cross section produced by the present formulae for compound nuclei of atomic number range 57≤Z≤71



The comparison of the fusion fission cross section produced by the present formulae for compound nuclei of atomic number range 57≤Z≤71 is as shown in the figure 1. Our analysis is based on the experimental cross sections. Parameterization of fusion-fission cross section of compound nuclei of **57≥Z≥71 is** considered. We have considered 168 experimental fusion-fission reactions of different energy ranges available in the literature. The coefficient of determination $<R^2>$ of experimental values by present formula is 0.97.

The values produced by the present work agree well with the experiments. This comparison also shows that the value produced by the present work agrees well with the experiments. The agreement of present work with the experiment may leads to the conclusion that these formulae may be used to obtain fusion fission cross section of compound nuclei of atomic number range 57≤Z≤71. Our analytical parameterized values are in very close agreement with actual as well as experimental values. Note that our parameterizations depend on the charges and masses of the compound nuclei and fission fragments only. This definitely introduces great simplification in the calculation of fusion fission cross sections. These results can be used as a guide line for estimating the fusion fission cross sections in those cases where measurements do not exist and also for the study of new nuclei yet unexplored.

In summary, the present parameterization of the fusion fission cross-sections allows to estimate values of these cross-sections with very good accuracy. Therefore, the parameterization can be applied for interpolation and/or extrapolation of the present experimental information on fusion fission cross sections to the fission fragment or energies not available experimentally.

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