Fission yield calculations for ^{238}U(^{18}O,f) reaction

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Introduction

Nuclear fission is a complex process involving large scale collective rearrangement of nuclear matter. The prediction of the mass, charge and energy distribution in the fission process is still a challenge for the nuclear theory. These distributions are decided during saddle to scission transition and are closely related to the scission configuration. Various models have been put forward to describe the fission fragment mass distribution as well as the shapes of the fragments at scission [1].

The fragment mass distribution is one of the most important observable of the fission process. New experimental studies employing the γ-γ coincidence technique to obtain the independent yield of the fragments has enabled the identification of fission yields in A and Z for various fissioning systems [2, 3]. These kind of data give more comprehensive view on the influence of shell effects and pairing correlations on the fission-fragment mass and nuclear-charge distributions. In our earlier work, the yield distribution of correlated fragments (Sr-Sm, Zr-Nd, Mo-Ce, Ru-Ba, Pd-Xe, Cd-Te, and Sn-Sn isotopes) produced in the ^{238}U(^{18}O,f) reaction had been obtained employing the γ-γ coincidence technique [2]. In this contribution, the fission yields predictions of the GEF code [4], for the ^{238}U(^{18}O,f) reaction are presented.

GEF Calculations

The experiment was carried out using thick ($\sim$ 15 mg/cm^2) self-supporting ^{238}U target, bombarding ^{18}O beam at energy E_{lab} = 100 MeV [2]. The beam energy loss (calculated using SRIM) in the target is $\sim$ 23 MeV. The GEF model describes the observables for fission of a compound nucleus for any entrance channel, with a given excitation energy and angular momentum. To carry out the GEF calculations the target was considered to be divided in 10 equal segments of thickness 1.5 mg/cm^2 each. The average excitation energy, $\langle E^* \rangle$, and angular momentum, $\langle l \rangle$, of the compound nucleus, ^{256}Fm, in each of these segments were calculated and given as the input to GEF. For the first segment facing the incident beam, the compound nucleus, ^{256}Fm, has $\langle E^* \rangle \sim 54$ MeV and $\langle l \rangle \sim 23$. The fission yields obtained from the individual segments were weighted with the average fusion cross section of that segment, to get the fission yields for the thick target. The average fusion cross section and angular momentum were calculated using the code CCFULL [5].

Mass distribution

The mass distribution for the ^{238}U(^{18}O,f) reaction [2], is shown in Fig. 1, along with the fit to the experimental data and the GEF predictions. The mean values and width of these distributions are listed in Table I. It is to be noted that the independent yield obtained from the γ-γ coincidence technique represents the secondary fragments, thus the ex-

TABLE I: Mean Values and Widths of Fission-Fragment Distributions.

	mean-value $\langle m \rangle$	mass-width σ_m
Fit to experimental data	123.8(5)	20.6(6)
GEF (primary)	127.93(3)	18.85(3)
GEF (secondary)	123.4(4)	18.3(1)

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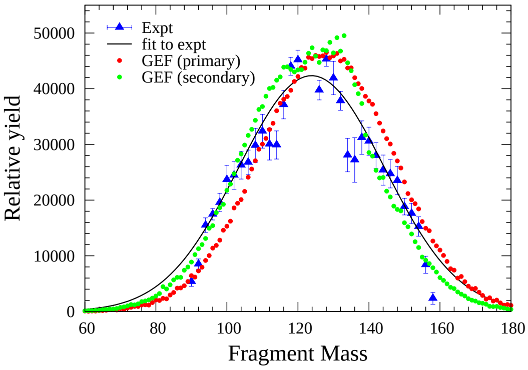

FIG. 1: The experimental mass distribution obtained in ^{238}U(^{18}O,f) reaction [2] along with the calculations. The GEF calculations has been normalized with the experimental data for comparison. The term primary refers to the yield before the emission of prompt neutrons and secondary refers to the nuclei formed after neutron emission but before any β decay has occurred.

perimental data is compared with the GEF calculations for the secondary yields. As it can be seen in Table I, the mean-value, $\langle m \rangle$, of the mass distribution calculated from the GEF code is in good agreement with the experimental data. However the GEF under-predict the mass width, σ_m, in comparison to the experimental value.

Isotopic yield distribution

The Isotopic yield distribution characterizes the mass division for fixed given Z (charge) of the fragments. The Isotopic yield follow a Gaussian distribution:

$$\frac{C}{\sigma_A \sqrt{2\pi}} e^{-(x-A_p)^2/2\sigma_A^2}$$

where C is the normalization constant and the parameters A_p and σ_A are the most probable mass and width of the distribution, respectively. The values of these distribution parameters, A_p, and σ_A, obtained form the experimental data and GEF calculations for various Z are listed in Table II. The GEF predictions are in good agreement with the experimental data. As it can be seen from Table II that for various charge splits, the GEF calculations reproduces the parameters, A_p, and σ_A, as they are obtained from the experiment.

TABLE II: Isotopic yield distribution parameters, the most probable mass, A_p, and the width, σ_A of the distribution.

	A_p (expt)	A_p (cal)	σ_A (expt)	σ_A (cal)
Sr	92.65(3)	92.42(3)	2.94(4)	1.93(3)
Zr	98.4(2)	97.8(2)	1.7(2)	2.4(2)
Mo	102.4(3)	102.70(1)	2.7(2)	2.03(1)
Ru	107.6(1)	107.65(2)	2.5(1)	2.09(2)
Pd	112.77(4)	112.83(1)	2.51(5)	2.15(1)
Cd	118.1(3)	118.02(4)	2.1(3)	2.24(4)
Sn	121.3(2)	123.53(2)	1.9(2)	2.15(2)
Te	127.7(3)	128.74(3)	2.1(2)	2.11(3)
Xe[a]	132.4(5)	133.42(2)	2.1(4)	1.95(2)
Ba[a]	139.1(2)	137.9(1)	1.9(1)	2.0(1)
Ce	143.8(2)	143.1(1)	2.3(2)	2.6(1)
Nd	148.2(5)	148.68(3)	2.2(6)	2.50(3)
Sm	154.7(3)	153.7(1)	2.5(3)	2.5(1)

[a] One outlier from the experimental data was excluded to obtain the distribution parameters.

The data analysis is in progress, and the results in detail will be presented in the symposium.

Acknowledgments

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