Isospin Conservation in the fission dynamics of ^{235}U(n_{th}, f)

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Introduction

For a better understanding of the dynamics of the nuclear fission process, it is necessary to have accurate knowledge of many experimental observables. One such important observable is the relative isotopic yield distributions of the complementary fission fragments, and, in turn, the total fission fragment mass distribution. Contrary to the earlier belief that the isospin quantum number remains valid and pure only in lighter nuclei, theoretical developments later proved it to be wrong, in general [1]. With the availability of data on neutron-rich nuclei from fission experiments, it has been observed that the isospin quantum number regains its purity in these heavier nuclei. In the past few years, this concept of "isospin conservation"[2] has been successfully applied to the heavy ion-induced fission systems like ^{208}Pb(^{18}O, f) and ^{238}U(^{18}O, f) [3, 4] to reproduce the experimental isotopic yield distribution.

In the present work, calculations following isospin conservation formalism were carried out to obtain isotopic yield distribution from ^{235}U(n_{th}, f) reaction. The calculated results were then compared with the experimentally available data from the same aforesaid reaction. It is to be noted that only the even-even complementary fission fragments were considered in this work due to their unambiguous availability in literature following prompt γ ray spectroscopy analysis [5].

Formalism

Isospin follows the SU(2) algebra as that of spin quantum number. By definition, both the proton and the neutron have been assigned a total isospin T = 1/2 and the third component T_3 = +1/2 for proton and -1/2 for neutron. In assigning the total isospin to the mass numbers, we have followed the methodology provided in [6]. In the present reaction, the total isospin of the target (T_x) and the projectile (T_y) are 51/2 and 1/2 respectively. We have assumed that both the target and the projectile are in their ground states, and we have $T_x = T_{3x}$ and $T_y = T_{3y}$, where T_{3x} and T_{3y} are the third component of isospin for the target and projectile, respectively. From the conservation of the isospin, the third component of the isospin of the compound nucleus(T_{3CN}), ^{236}U is 26. Thereby, the total isospin of ^{236}U is 26 since $T_{CN} \geq T_{3CN}$. Then, Kelson's argument which states that fission favors the formation of IAS (Isobaric Analog State) in neuton-rich fragment nuclei have been applied to assign the total isospins to the individual mass numbers, starting from 82 to 150 mass unit. This result has been shown in Fig. 1. For each mass number, three isobars have been maintained so that the maximum T_3 value out of the isospin triplet can be assigned as the total isospin. In the latter part of the calculation, an auxillary concept of residual compound nucleus has been utilizied. By using the following equation, we then assign the isospin to the individual fission fragments.

$$| T_{CN} - q/2 | \leq T_{RCN} \leq (T_{CN} + q/2), \quad (1)$$

Here T_{RCN} is the total isospin of the residual compound nucleus, and q is the number of emitted neutrons. Then, by only considering the isospin part of the total wave function, the Clebsch-Gordon Coefficients(CGC)

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for all combinations of fragments were calculated. Note that the T_{F1} and T_{F2} represent the total isospins assigned to the fission fragments, and T_{3F1} and T_{3F2} are the corresponding third components, respectively. By squaring these amplitudes, one can obtain the relative yields as follows:

$$I = \langle T_{F1} T_{F2} T_{3F1} T_{3F2} \mid T_{RCN} T_{3RCN} \rangle^2, \quad (2)$$

Results and discussion

As the neutron multiplicity for the present system is 2.42, a well documented value from the literature, we have considered 0, 2 and 4 neutron emission channels for the calculations. In Fig. 1, the assigned total isospin values for each corresponding mass number have been shown. The squared boxes depict the final assigned values with repect to the three adjacent isobaric analog states for each mass number.

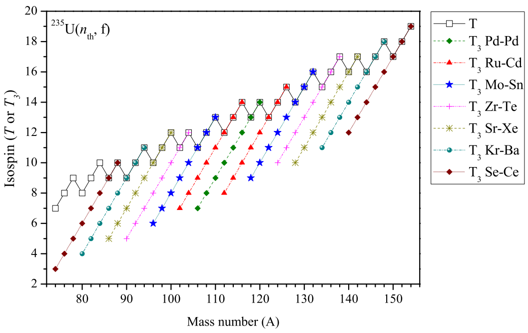

FIG. 1: Pair-wise assignment of the total isospin quantum number with respect to the corresponding mass number.

The comparison between the experimental isotopic yields and the predicted results following isospin conservation formalism for the Kr-Ba and Sr-Xe complementary fragment pairs is shown in Fig. 2. The experimental results have also been compared with the calculated yields from the GEF (**GE**neral description of **F**ission) simulation package [7]. in Fig. 2. As is evident from the figure, the experimental results are in quite good agreement with those obtained from the calculations using the two different aforementioned approaches.

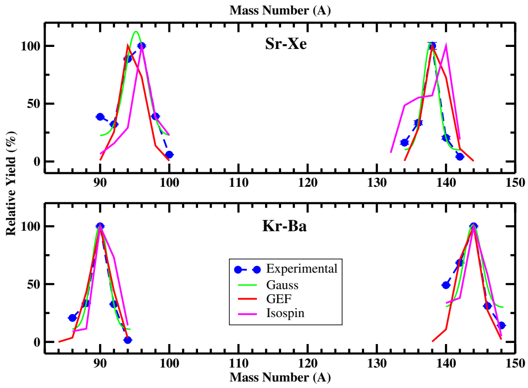

FIG. 2: Comparison of experimental and calculated results on relative isotopic yield distribution for two different pairs of complementary fission fragment nuclei. The evolution of calculated results following both isospin conservation and the GEF formalisms are depicted.

Detailed calculation and results will be presented during the symposium.

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