Ternary fission analysis of ^{56}Ni nucleus keeping α or 2α as the third fragment

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1. Introduction

The study of nuclear fission, particularly ternary fission, has been an area of growing interest in the nuclear physics community due to its potential to reveal deeper insights related to nuclear stability. In past years, different attempts were made to explore this mode in ground state and excited state of the nucleus. An experimental attempt was made by Oertzen et al. [1] to study the ternary decay dynamics in ^{32}S+^{24}Mg reaction, where the third fragment identification is made using missing mass method. It was concluded that there is possibility of emission of α, 2α,3α and 4α as middle fragment along with two heavy fission fragments and their respective proton numbers are identified. In the present work, the probable fission fragments are identified using quantum mechanical fragmentation theory (QMFT) based approach. The fragmentation potential is calculated by using the the ground state binding energies (GSBE) and the temperature dependent binding energies (TDBE) and a relative comparison is made. The methodology used in the present work is briefly dicussed below:

2. Methodology

In the present work, the fragmentation analysis is carried out using QMFT. The fragmentation potential is calculated as [2] :

$$V = \sum_{i=1}^{3}\sum_{j>i}^{3} B_i(T) + V_{Cij} + V_{Pij} \quad (1)$$

$$B_i(T) = \sum_{i=1}^{3}[V_{LDM}(A_i, Z_i, T)] + \sum_{i=1}^{3}[\delta U_i]exp(-T^2/T_0^2) \quad (2)$$

Here, V_{LDM}, the T-dependent macroscopic liquid drop model is taken from Davidson *et al.* [3], which is based on the semi-empirical mass formula. δU represents the 'empirical' microscopic shell correction.The details can be seen in ref.[4]. The relative separation among the fragments is $R_{ij} = R_i + R_j + s_{ij}$. Here R_i and R_j are the radius vectors of decaying fragments and s_{ij} is the surface separation between them. It is relevant to mention here that the s_{ij} is taken in reference to Collinear configuration .

3. Results and discussions

The objective of this work is to do a comparative analysis of α and 2α accompanied ternary fission from ^{56}Ni nucleus using GSBE and TDBE. First of all, the fragmentation potential is calculated and plotted as a function of fragment mass A_2 by taking T=0 MeV and T= 3.59 MeV for A_3=α and shown in Fig.(1).(a). It can be noted from the figure that the fragmentation structure have lower magnitude for T=0 MeV as compared to T= 3.59 MeV case. Additionally, lighter fragments have more emission probability as compared to heavy fission fragments due to lower magnitude for both of the cases. In the present work, we are interested in the fission region of the fragmentation structure. The dips in the fragmentation structure give the most probable fission fragments. In the experimental

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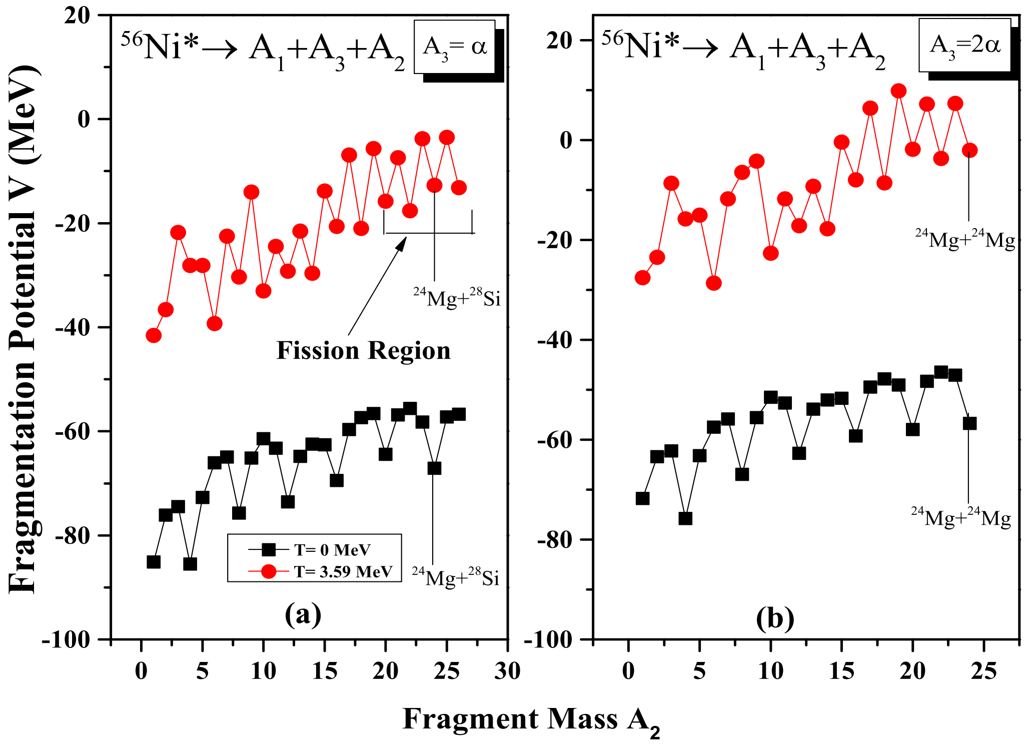

FIG. 1: The Fragmentation potential (V) plotted for ^{56}Ni nucleus as a function of fragment mass A_2 for T=0 MeV and T= 3.59 MeV for the (a) A_3=α and (b) A_3= 2α Decay.

attempt [1], the proton number of the α accompanied ternary fission is given as Z_1=12 and Z_2=14. The mass number of these fragments can be identified using the dips of the fission region. The identified fragment combination (A_1+A_2) of these proton number are ^{24}Mg+^{28}Si for both of cases (T= 0 and 3.59 MeV). After this, the fragmentation potential is plotted as a function of fragment mass A_2 for T=0 MeV and T= 3.59 MeV for A_3=2α and shown in Fig.(1).(b). There is change in the magnitude and structure of the fragentation potential and the mass number of the probable fission fragments become ^{24}Mg+^{24}Mg. The α particle accompanied fission has higher emission probability as compared to 2α particle partnered emission due to lower magnitude of fragmentation potential. Similar, results were obtained in the experimental yield. It will be of further interest to include the angular momentum effects in the present work.

References

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