Energy dissipation in the cold fission of ^{252}Cf

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Introduction

The conversion of energy of collective nuclear motion into internal single particle excitation energy is one of the modes of nuclear energy dissipation. Dissipation and its relation to pair breaking is one of the challenges in nuclear field. A characteristic of low energy fission is odd –even effect. Odd-even staggering in the mass or charge yields and in the total kinetic energies [1] will be of useful to analyze dissipation energy. The odd even effects in the charge distribution of cold fission fragments can be analysed to extract information on the energy dissipation during the passage from the first potential well towards the scission point through the fission barrier [2]. The Q value during a fission process is decomposed into the total kinetic and excitation energies (TKE and TXE).

i.e., $Q = TKE + TXE$ (1)

In normal fission phenomena (known as hot fission) a fraction of the energy released during fission is spent to deform and excite the fragments. Cold fission also known as neutronless fission is a subset of fission. These cold fission events are of interest because they are events where most of the energy is dissipated through either kinetic energy or deformation of the nascent fragments instead of spending on excitation and neutron emission. Cold fission is an excellent source to measure odd-even effect which can provide insight about nuclear structure such as energy levels, deformation etc., and will help us to understand the fission path from saddle point to the scission point [3].

In this work we present an estimation of the odd - even staggering, energy dissipated and its dependence on fragment mass for different cold fragmentations of ^{252}Cf based on the isotopic yield computed by A. Sandulescu et al., [4].

Theory

Cold fission can be treated in analogy to alpha and cluster decay by the penetrability through the potential barrier [5]. For a given mass and charge split the absolute yields for the fragments in cold fission can be taken as proportional to the decay constant $\lambda = \upsilon P(A_L, Z_L)$ where υ is the assault frequency ,which is the no. of collisions on the barrier per second and $P(A_L,Z_L)$ the penetrabilty. The relative isotopic yield is taken as the ratio of the penetrability through the potential barrier of a given fragmentation to the sum of penetrabilities of all possible neutronless fragmentations and can be expressed as:

$$Y(A_L, Z_L) = \frac{P(A_L, Z_L)}{\sum_{A_L, Z_L} P(A_L, Z_L)} \quad (2)$$

Sandulescu et al. [4] calculated the isotopic yield of ^{252}Cf using M3Y potential by the double folding procedure based on a cluster model similar to the one-body model used for the description of cluster radioactivity. The above mentioned data have been used in the present work to investigate the energy dissipation. The cold fission yields show that many odd-odd splitting have values larger than the neighbouring even-even fragmentations. The odd-even staggering is given by:

$$\delta_Z = Y_e - Y_o \quad (3)$$

where Y_e and Y_o respectively are the yield for even and odd charge number with δ_Z being positive for enhanced even yields. The even-odd staggering observed in the experimental fission-fragment nuclear-charge yields is investigated over a wide systematic of fission fragments measured at Lohengrin [6]. In normal fission, for all compound nuclei undergoing fission with even Z, the proton odd-even effects of the fragments found to be positive. The amplitude of the even-odd staggering is linked to the pair breaking and dissipation during the deformation in the fission process [6]. The dissipation energy is connected to the odd-even staggering through the relation[7]:

$$E_{diss} = -4 \ln\delta_z \text{ (MeV)} \quad (4)$$

A quantity that reflects the internal structure of a nucleus during fission process is mass asymmetry parameter(η_A) which is defined as:

$$\eta_A = \frac{A_H - A_L}{A_H + A_L} \quad (5)$$

where A_H is mass number of heavy fragment and A_L mass of the light fragment produced. The experimental data for the spontaneous fission of ^{252}Cf and ^{248}Cm indicate a preference for cold fragmentations with both the partners are having pronounced ground-state deformations and masses $100<A_L<114$, $140<A_H<152$ respectively [8,9]. In

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