Odd even effect in the cold fission of ^{252}Cf

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Introduction

The odd-even effects in the fragment yields as a general phenomenon were first disclosed in a comprehensive survey of data existing in 1969 for thermal neutron fission of ^{236}U by Wahl et al. [1] and connected it to the pair-breaking probability. The odd even effect as one of the prominent structural effects in normal (hot) nuclear fission at low excitation energies and a quantitative and systematic analysis of odd-even effects was reported by Amiel and Feldstein [2].

A phenomena in which odd even effect absent, is cold fission which is the limiting case of fission in which the Q value exhausts the TKE. The first direct observation of these cold neutronless binary fragmentations in the spontaneous fission of ^{252}Cf was made by using the multiple Ge detector Compact Ball facility at Oakridge national laboratory[3]. Higher yields for the odd-odd fragmentations of ^{252}Cf are also observed by Hambsch et al., [4] for low TXE values (TXE < 9 MeV). There is no odd-even effect in the mass yield, except when (Q_{MAX} - TKE) becomes less than or equal to 3 MeV [5]. The dominance of odd fragmentation in the cold fission of ^{233}U for very low TXE has also been reported by Schawb et al., [6]. Hence a very characteristic feature of cold fission data is the comparable yields for even and odd-mass fragments, up to the maximum permitted values of TKE. Therefore cold fission is an excellent source to understand odd-even effect which can provide insight about nuclear structure and will help us to understand the fission path from saddle point to the scission point [7]. It is hoped that in these cold fission phenomena, the nuclear shell and pairing effects should be more evident due to the fact that quantum mechanical phenomena such as superfluidity of nuclei and zero point oscillations have a strong influence on the fission process [8].

The odd-even effect in the charge yields can be characterized by the quantity the 'odd even enhancement factor',

$$\delta_Z = \frac{Y_e - Y_0}{Y_e + Y_0}.$$

Wh where Y_e and Y_o respectively are yields for even and odd charge number and δ_Z being positive for enhanced even yields. In normal fission, for all compound nuclei undergoing fission with even Z the proton odd-even effects of the fragments turn out to be positive. The odd-even effect in neutron number is considerably smaller than the even-odd effect in proton number and there is an increasing of δz and δ_N as a function of fragment kinetic energy observed [9]. The increasing of δ_Z and δ_N as a function of fragment kinetic energy suggests that a strong hindrance of odd mass (even Z-odd N or odd Z-even N) would be found at higher fragment kinetic energies [10] which is against experimental results. A zero or negative enhancement factor is expected in the cold fission which is characterized by high fragment kinetic energies.

Cold fission can be treated in analogy to alpha and cluster decay by the penetrability through the potential barrier [11]. 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 Sandulescu et al., [12] calculated isotopic yields 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 which have been used to investigate the odd-even effect in the present work. The relative isotopic is taken as ratio of the penetrability through the potential barrier of a given fragmentation over the sum of penetrabilities of all possible neutronless fragmentations and can be expressed as:

$$Y(A_L, Z_L) = \frac{P(A_L, Z_L)}{\sum_{A_L, Z_L} P(A_L, Z_L)}$$ in which penetrability $P(A_L,Z_L)$ is calculated using M3Y potential. In this work we present an estimation of the odd - even enhancement factor, its dependence on shell effect for different cold fragmentations of ^{252}Cf from the isotopic yield computed in [12].

Results & Discussion:

The calculated odd even enhancement factor shows negative values in the region $100 < A_L < 114$ implying that odd fragmentations are dominated than even fragmentation. This is in agreement with the experimental data of the cold fission of ^{252}Cf [13]. It has been found by Trochon et al., [14] that the cold fission yields are influenced by the level density of the fragments, since in the vicinity of the ground state, the level densities of odd mass nuclei are much larger than for even nuclei.

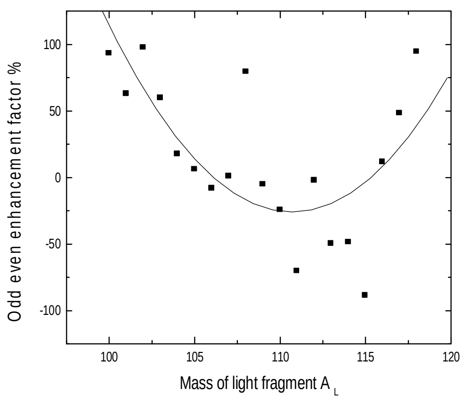

Fig.1: Plot of odd even enhancement factor (%) with light fragment mass.

The odd-even effect as function of mass $\delta_z(A_L)$ versus the light-fragment mass number (A_L) in the region 100-114 is shown in figure 1. It is found that the odd-even difference strongly fluctuates in these regions. A negative enhancement factor is found in the region A_L = 104 - 117. The lowest odd - even enhancement factor corresponds to the splitting 115/137 in which a shell closure at 50 for proton, and 82 for neutrons are observed which implies the fact that shell effect plays an important role in the odd-even difference by enhancing the odd-odd fragmentation.

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