Binary fission of ^{266}Lr

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Introduction

A nuclear reaction in which a heavy nucleus splits into two fragments of almost equal masses along with the release of energy is called binary fission (BF). Binary fission was first observed by Otto Hahn and F Strassmann [1]. A V Andreev [2] studied the charge number distribution, mean kinetic energy of ^{252}Cf. Sowmya et al., [3-4] systematically studied competition between binary fission and ternary fission of $^{232-238}$U and ^{281}DS along with cluster radioactivity for ^{281}D, reported that binary fission is possible in $^{232-238}$U and alpha decay is dominant in ^{281}Ds Sharma et al., [5] used preformed cluster model and three cluster model to study the binary and ternary fission of ^{253}Es and observed that relative yield of binary fragments is more than yield of ternary fission. Using the interacting barrier potentials Santhosh et al, [6] studied the cold binary fission of even-even $^{244-258}$Cf and from this study it was found that ^{244,246,248}Cf has highest yield with Pb as one of the fragments and ^{250,252}Cf has highest yield when Hg as one fragment, in case of ^{254,256,258}Cf has highest yield when Sn as one of the fragment.

Unik et al., [7] experimentally studied the binary fission of helium ion induced fission of ^{209}Bi, ^{226}Ra, ^{238}U. By calculating the potential energy and with binuclear system model, Andreev et al., [8] studied the charge, total kinetic energies for binary fission of actinides. Manjunatha et al., [9] investigated on the binary fission of super heavy nuclei ^{299}121 and found that La and Gd with N=82 has the maximum penetration probability and probable binary fission fragments because of the presence of magic neutron number by ^{139}La. Cold-fission modes in ^{252}Cf [10] was studied by Sandulescu et al., by considering cluster model. In all these literature survey we found there is lack on the study of binary fission of lawrencium. So this motivated us to carry out this present work.

Theoretical Frame work

The binary fission half-lives is evaluated as follows

$$T_{\frac{1}{2}} = \left(\frac{\ln 2}{\lambda}\right) = \left(\frac{\ln 2}{\nu\, P}\right) \quad (1)$$

Where λ is the decay constant and ν is the assault frequency. The probability of penetration through the barrier is $P = [1+\exp(K)]^{-1} \cong \exp(-K)$, where K is the action integral. Hence, barrier penetrability P with the ternary fragments is expressed as;

$$P = \exp\left\{-\frac{2}{\hbar}\int_{Z_1}^{Z_2}\sqrt{2\mu(V-Q)\,dz}\right\} \quad (2)$$

The amount of energy released during binary fission is as follows;

$$Q = M - \sum_{i=1}^{3} m_i > 0 \quad (3)$$

Here M and mi are the mass excess of the parent and fission fragments. The total interacting potential consists of Coulomb and nuclear proximity potential and it is expressed as;

$$V = \sum_{i}^{3}\sum_{j>i}^{3}(V_{Cij} + V_{Pij}) \quad (4)$$

Where, V_{cij} and V_{pij} are the Coulomb and proximity potential functions and it is evaluated as explained in literature [11]. The universal function is given by;

$$\Phi(S_0) = \begin{cases} -3.437\exp\left(-\frac{S_0}{0.75}\right) & \text{for } S_0 > 1.2511 \\ \left(-\frac{1}{2}\right)(S_0-2.54)^2 - 0.0852\,(S_0-2.54)^3 & \text{for } S_0 < 1.2511 \end{cases} \quad (5)$$

The turning points are determined as explained in literature [11]. Where Q is the decay energy.

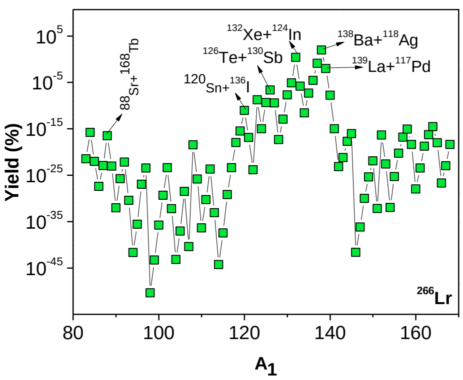

Fig 1: Variation of yield with respect to mass number of fission fragment A_1 for the parent nuclei ^{266}Lr.

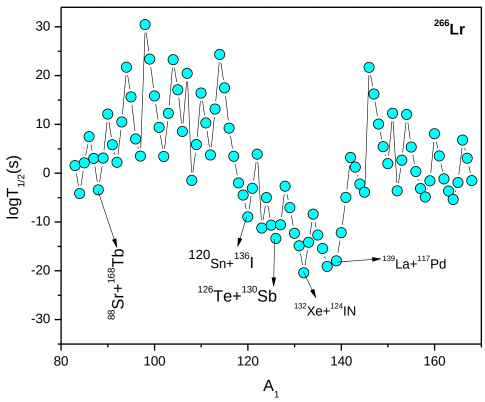

Fig 2: Variation of log $T_{1/2}$ with respect to mass number of fission fragment A_1 for the parent nuclei ^{266}Lr.

Results and Discussions

The total potential of ^{266}Lr is evaluated using Coulomb and proximity potentials. Mass excess of the parent and the emitted nuclei have been calculated from the latest mass excess table [12]. The binary fission half-lives and yield are evaluated as explained in literature [11]. The variation of percentage of yield with respect to mass number of the A_1 is shown in fig 1. The peaks correspond to the fission fragments having maximum yield. Variation of logarithmic half-lives with mass number A_1, is plotted as shown in fig 2, here we have noticed the smaller half-lives for the fragments ^{88}Sr+^{168}Tb, ^{120}Sn+^{136}I, ^{126}Te+^{130}Sb, ^{138}Ba+^{118}Ag, and ^{139}La+^{117}Pb. The maximum yield and minimum half-lives corresponding to each fission fragment combination is identified. The maximum value of relative yield is observed for the following fission fragments ^{88}Sr+^{168}Tb (N=50), ^{120}Sn+^{136}I (Z=50), ^{126}Te+^{130}Sb (Z=52), ^{138}Ba+^{118}Ag (N=82), and ^{139}La+^{117}Pb (N=82). These maximum peaks are attributed to the presence of magic nuclei or near magic nuclei, which enhance nuclear stability and influence fission fragment yields.

Conclusions:

Binary fission of ^{266}Lr is studied using Coulomb and proximity potential model. The fission fragment that are identified for the binary fission for ^{266}Lr consists of fission fragment combination in which the proton number or neutron number of the fission fragments are magic nuclei and has shorter half lifes and shows a probability of binary fission. This study plays a curial role in upcoming experiments of binary fission of ^{252}Cf.

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