α and heavy LCP accompanied ternary fission of superheavy nucleus $^{298}_{114}$X

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Introduction

The island of stability in superheavy region were theoretically predicted to be around Z=114, 124, 126 with N=184, and Z=120, with N=172 by various authors. In 1965, Myers and Swiatecki [1] reported that the shell corrections added to liquid drop model indicates the possibility of closed shells at Z=114 and N=184, and it is later confirmed by Sobiczewski et al. [2] and Nilsson et al. [3]. The synthesis of superheavy element were predicted by various authors [4, 5], with the use of a highly neutron rich beam of ^{48}Ca on neutron rich actinide targets and succeeded in synthesizing few superhevay elements in cold fusion reactions. The dominant decay mode of superheavy nucleus is α-decay. But theoretical attempts were also made to look for heavy particle emission from superheavy nuclei.

On the basis of liquid drop model it was shown theoretically that for increasingly heavier nuclei, fission into three and more than three were favorable than binary fission and the breaking of a heavy nucleus into three or more than three fragments would release more energy. Greiner predicted that ternary fission could be a possible decay mode for superheavy nuclei though fission remains a non competing decay mode, with respect to α-decay. Exotic ternary fission is a process, in which a heavy radioactive nucleus undergo fission into three fragments. Till now no theoretical attempts were made to explore the possibility of ternary fission in the superheavy mass region. Schultheis et al. [6] calculated the barrier of ternary fission for the superheavy nucleus $^{298}_{114}$X and predicted that the barrier for ternary fission exceeds the binary fission only by 10% for the most stable superheavy nuclei. In the present work using the Three Cluster Model (TCM) [7] proposed by us, we study the possibility of ternary fission in the superheavy nucleus $^{298}_{114}$X for various third fragments from helium through calcium, accompanied with main fission fragments. The ternary fragmentation potential in TCM is defined as

$$V_{tot} = \sum_{i=1}^{3}\sum_{j>i}^{3}(B_{ii} + V_{ij}) \quad (1)$$

where B_{ii} are the binding energies of the three fragments. V_{ij} is the sum of Coulomb interaction and the short range Yukawa plus exponential nuclear attractive potential amongst the three fragments. The yield in TCM is the normalized penetrability, calculated as

$$Y(A_i, Z_i) = \frac{P(A_i, Z_i)}{\sum P(A_i, Z_i)} \quad (2)$$

The penetrability P is the WKB integral

$$P = exp[-\frac{2}{\hbar}\int_{s_1}^{s_2}\{2\mu[V(s) - Q]\}^{1/2}ds], \quad (3)$$

calculated analytically, with s_1(s_1=0, the touching configuration) and s_2 ($V(s_2)$=Q), as the first and second turning point respectively. μ is the reduced mass of the fragments and Q is the available energy of the fragments to cross the ternary potential barrier.

Results and Discussion

The calculated ternary fragmentation potentials of $^{298}_{114}$X for different third fragments such as ^{4}He, ^{10}Be, ^{14}C, ^{46}Ar, ^{48}Ca and ^{50}Ca are presented in Fig. 1. These third fragments are identified with proper charge minimization of potential energy for the

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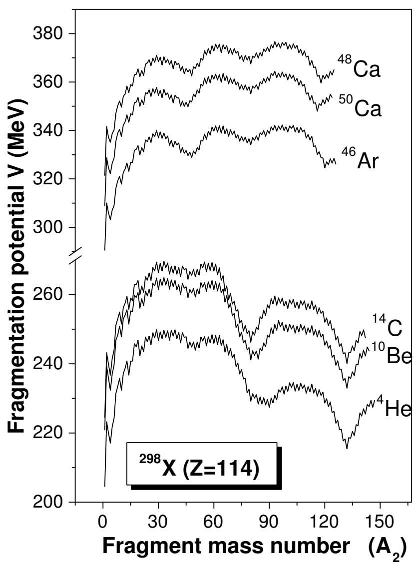

FIG. 1: The ternary fragmentation potential of $^{298}X_{114}$ for different third fragment considered.

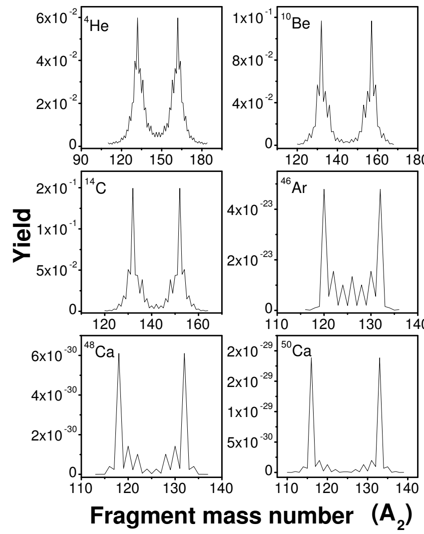

FIG. 2: The calculated yield w.r.t fragment mass number for different third fragment considered.

respective mass numbers as in [7]. In Fig. 1 the potential for ^{4}He accompanied fission lies lowest than the other third fragments. There exist three cold valleys in the potential energy surface (PES) for all the third fragments, and the third one near the symmetric region lies lower and have sharp minimum. The following fragment combinations ^{162}Sm+^{132}Sn+^{4}He, ^{156}Nd+^{132}Sn+^{10}Be, ^{152}Ce+^{132}Sn+^{14}C, ^{132}Sn+^{120}Pd+^{46}Ar, ^{132}Sn+^{118}Ru+^{48}Ca, ^{132}Sn+^{116}Ru+^{50}Ca has minimum in the near symmetric region of PES. In all the cases any one of the fragments (either A_1 or A_2) associates itself with the doubly closed shell nucleus ^{132}Sn (N=82, Z=50). Among the two Ca isotopes considered (^{48}Ca and ^{50}Ca) ^{50}Ca lies minimum in PES than ^{48}Ca. Though the fragmentation potential reveals some information the complete mass distribution effect can be seen only through the yield calculations. The calculated yields are presented in Fig.2 in which each panel corresponds to different third fragments. In all the cases there is a broad mass spectrum having a distinct maximum for the same fragment combination that were identified in the PES. For the light clusters (^{4}He, ^{10}Be, ^{14}C) the distribution is wide but the heavy clusters (^{46}Ar, ^{48}Ca and ^{50}Ca) have narrow distribution and sharp maximum. The magnitude of the yield of light clusters are higher than the magnitude of heavy clusters. In particular, the possibility of ^{4}He accompanied fission seems to be more probable with respect to other third fragments.

References

[1] W. D. Myers et al., Report UCRL, p. 11980 (1965).

[2] A. Sobiczewski et al., Phys. Lett. **22** 500 (1966).

[3] S. G. Nilsson et al., Nucl. Phys. **A** 131, 1 (1969).

[4] G. N. Flerov Âtom. Ener. **26** 138 (1969).

[5] R. K. Gupta et al., *Naturforsc* **32a** 704 (1977).

[6] H. Schultheis et al., Phys. Lett. **49B** 423 (1974).

[7] K. Manimaran et al., Phys. Rev. C **79**, 024610 (2009).