Competition between different decay modes in ^{279}Ds

N.Sowmya[1&2], H C.Manjunatha[1]*
[1]Department of Physics, Government College for Women, Kolar-563101, Karnataka, INDIA
[2]Deptartment of Physics, BMSIT&M, Affiliated to VTU, Bangalore.
(*Email: manjunathhc@rediffmail.com)

Introduction

The compound nucleus formed through fusion undergoes different decay modes such as binary, ternary, cluster and alpha decay. The atomic number greater than uranium is unstable and undergoes different decay modes. The study of these different decay modes finds very important role in identifying the existence of superheavy nuclei. Flerov and Glasoe [1,2] experimentally studied the spontaneous fission of uranium atom. Tsien San-Tsiang et al.,[3] experimentally observed the presence of third fission fragment in uranium. Rose and jones [4] observed natural radioactivity in ^{235}U emitting ^{14}C to ^{209}Pb. Rutherford [5] experimentally identified alpha decay. Dong and Ren [6] proposed new binding energy formula for superheavy nuclei and reproduced the alpha decay half-lives for Z=110 to 118. They also explained proton drip line of Md(Z = 101) to Ds (Z = 110). Gonnenwein [7] studied the spontaneous decay modes in actinides. Kozulin et al.,[8] studied most probable fission fragments and total kinetic energy with in superheavy nuclei Z=110-116 by calcium induced reactions. Using unified model Mirea et al., [9] theoretically studied the disintegration modes such as fission, cluster emission and alpha decay in ^{222}Ra. Morita et al,. [10] experimentally studied the production of ^{271}Ds through the fusion of lead with nickel and also studied decay chains of ^{271}Ds. Manjunatha and Sowmya [11] studied different decay modes in Z=126 and identified alpha decay is the most dominant decay mode in Z=126. Hence in the present work we studied different decay modes such as binary, ternary, cluster and alpha decay in ^{279}Ds. We compared fission half-lives of different decay modes with that of alpha decay. We also studied branching ratios of these different decay modes with alpha decay of ^{279}Ds.

Theory:

Binary and Ternary fission: To study the binary and ternary fission, we have considered the total potential which is sum of coulomb and nuclear potential. For nuclear potential part we considered the proximity method suggested by the previous worker [12].

Cluster decay and alpha decay:

To study the cluster decay and alpha decay, the expression for the Coulomb potential suggested by the previous worker [13] is used in the present calculation. For nuclear potential, we have used the proximity function defined specially for cluster/alpha [13]. The barrier penetrability *P* for ternary, cluster and alpha decay given by

$$P = exp\left\{ -\frac{2}{\eta}\int_a^b \sqrt{2\mu(V-Q)}dz \right\} \quad (1)$$

And half-life time is given by

$$T_{1/2} = \frac{ln2}{\lambda} = \frac{ln2}{\upsilon P} \quad (2)$$

Results and discussion

We systematically calculated the binary and ternary fission half lives of ^{279}Ds using coulomb and proximity potential. The amount of energy released (Q) during the process such as binary, ternary fission, cluster decay and alpha decay is calculated by using the following equation;

$$Q = \Delta M(A,Z) - \sum_i^n \Delta M(A_i, Z_i) \quad (3)$$

Where $\Delta M(A,Z)$ and $\Delta M(A_i, Z_i)$ are mass excess of the parent and emitted nuclei respectively. The mass excess values are taken from the available data [14-17]. We have studied binary and ternary fission half-lives for ^{279}Ds. We have also calculated half-lives for cluster and alpha decay using proximity potential. Fig 1 shows the variation of amount of energy released during the emission of different clusters ($^{12-14}C$, ^{14}N, $^{20-24}Ne$, $^{28-34}Si$, $^{36-44}A$, $^{40-48}Ca$) as a function of mass number of cluster from ^{279}Ds. From this study it is clear that as the mass number increases the amount of energy released also increases. Fig 2 shows the variation of logarithmic half-lives with mass of parent nuclei ^{279}Ds. The comparison of different decay modes are as shown in fig 3. This study shows minimum logarithmic half-lives for alpha decay.

Conclusions: The study of different decay modes such as binary, ternary cluster and alpha decay half-lives of ^{279}Ds shows that alpha decay half-lives are smaller than the other compared decay modes. From this study we conclude that alpha decay is most prominent in ^{279}Ds.

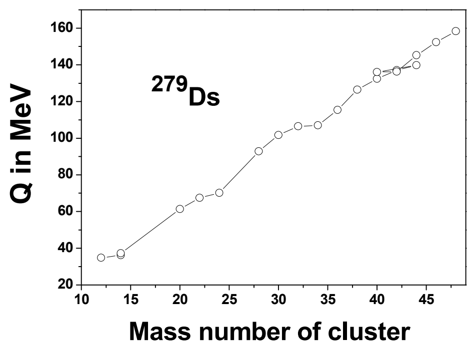

Fig 1: Energy released during the emission of different clusters ($^{12-14}C$, ^{14}N, $^{20-24}Ne$, $^{28-34}Si$, $^{36-44}Ar$, $^{40-48}Ca$) for ^{279}Ds as a function of mass number of clusters.

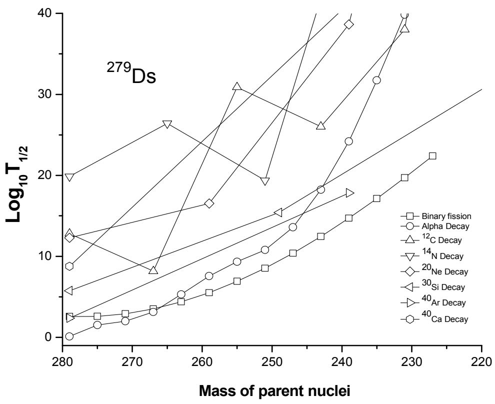

Fig 2: Variation of logarithmic half-lives as function of mass of parent nuclei for ^{279}Ds.

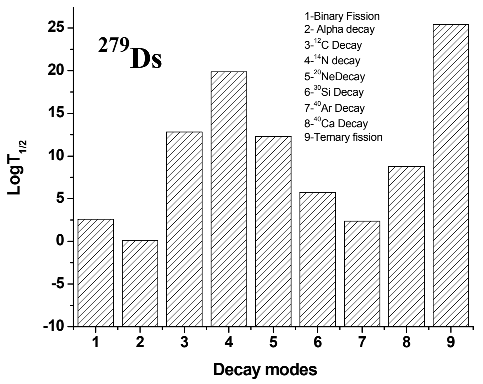

Fig 3: variation of logarithmic half-lives to that off different decay modes in ^{279}Ds.

References:

[1] G.N. Glasoe, J. Steigman, Phys. Rev. 58 (1940) 1.
[2]Petrjak Flerov, Phys. Rev. 58 (1940) 89.
[3]San-Tsiang Tsien, J. Phys. Radium 8 (1947) 165–178.
[4] H.J. Rose, G.A. Jones, Nature 307 (1984) 245.
[5] Ernest Rutherford, Disintegration of the radioactive elements, Harper's Monthly Magazine (January 1904) 279–284.
[6] Tiekuang Dong, Zhongzhou Ren, PHYSICAL REVIEW C 77, 064310 (2008).
[7] F. Gonnenwein Nuclear Physics A654 (1999) 855e-863c.
[8] E. M. Kozulin, G. N. Knyazheva, I. M. Itkis, M. G. Itkis et al Phy Rev C 90, 054608 (2014).
[9] Mihail Mirea, Radu Budaca, Aureliu Sandulescu , Annals of Physics 380 (2017) 154–167.
[10] K. Morita, K. Morimoto, D. Kaji, H. Haba et al., Eur. Phys. J. A 21, 257–263 (2004)
[11] H. C. Manjunatha, N. Sowmya, Nuclear Physics A 969,68–82 September 2017.
[12] Blocki.J, Randrup.J, Swaiatecki.W.J,Tsang.C.F (1977) Ann. Phys.(NY) 105, 427
[13]L. Zheng, G.L. Zhang, J.C. Yang, W.W. Qu, Nucl. Phys. A 915 (2013) 70.
[14]https://www-nds.iaea.org/RIPL-3/.
[15]H. Koura, T. Tachibana, M. Uno, M. Yamada, Prog. Theor. Phys. 113 (2005) 305.
[16]M. Kowal, P. Jachimowicz, J. Skalski, arXiv:1203.5013.
[17] H.C. Manjunatha, B.M. Chandrika, L. Seenappa, Mod. Phys. Lett. A 31(28) (2016) 1650162.