Search for cluster radioactivity in No Isotopes

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Introduction

Presently, the superheavy elements (SHE) investigations [1] are the salient multidisciplinary region for nuclear and atomic physics. Numerous studies have been carried out on the decay modes of heavy and superheavy nuclei using theoretical models as well as experiments. These decay modes (alpha, beta, and gamma) leaded by the synthesis of superheavy nuclei far away from the stability line. The discovery of cluster radioactivity like the isotopes of C and O, from heavy and superheavy nuclei precede to feasible shell or sub-shell closure at parent and daughter nuclei. In order to fabricate artificial superheavy nuclei, one must have detailed understanding of dominant decay mode among these decay modes and spontaneous fission(SF).

The main motive of our present analysis is to investigate the ground state properties, alpha decay, and cluster radioactivity of Nobelium isotopes in the region A∼248264. The decay properties helps to reveal spherical shell/sub-shell in the daughter nucleus. In the present work, the bulk properties of Nobelium isotopes have been examined with covariant density functional theory namely DD-ME2[2]. With in the relativistic models, the density dependent meson coupling and point coupling provides more appropriate description of the nuclear system microscopically. The Q-value is calculated from the binding energies of nuclei. Using Q-value, we calculated α-decay and cluster decay half-lives with semi-empirical relationships namely Univ2[3], universal decay law[4, 5].

Results and Discussion

In table I we have shown binding energies obtained by axial and triaxial symmetry compared with experimental data. Both axial and triaxial BE are nearly same and very close to experimental one. All the isotopes have ground state at $\gamma = 0^0$ except two isotopes ^{256}No, ^{258}No. For these two isotopes ground state is found at $\gamma = 5^0$, which is nearly equal to zero, therefore we can say there is no gamma dependency for all the isotopes. To check the extrastability, the two neutron separation (S_{2n}) have been evaluated which is not shown here. The gradual decrement in S_{2n} is found in the calculation which suggest that stability is going on decreasing as we increase the neutron number and calculated S_{2n} is very close to experimental results.

Table II contains the information about α-decay properties of nobelium isotopes. The calculated Q-values are in good agreement with experimental value. The decay half-lives are calculated with formulae named as Univ2, and UDL. UDL results somehow close to the experimental at the isotopes ^{252}No, ^{254}No, and ^{256}No. In Table II the half-life is small as per the UDL calculation at parent nucleus ^{248}No and ^{252}No which suggest the shell stabilization at daughter nucleus ^{244}Fm and ^{248}Fm. However, experimentally the shell stabilization is found at the daughter nucleus ^{244}Fm and ^{246}Fm.

For investigating cluster radioactivity in Nobelium isotopes, we have calculated decay half-lives for decaying ^{8}Be, ^{12}C, ^{16}O, and ^{28}Mg nucleus from nobelium isotopes. The decay half-lives for the nuclei ^{8}Be, ^{12}C, and ^{16}O are so large so that we can conclude that probability of decaying these nuclei is negli-

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TABLE I: The calculated Binding Energy, deformation parameter (β_2 and γ) of the ground state of isotopic series of Nobelium.

Nuclei	B.E(MeV) Expt.	B.E(MeV) Cal.	(β_2, γ)
^{248}No	1841.15	1841.75	(0.28,0)
^{250}No	1856.50	1857.59	(0.29,0)
^{252}No	1871.30	1871.72	(0.29,0)
^{254}No	1885.59	1885.33	(0.29,0)
^{256}No	1898.63	1897.77	(0.28,5)
^{258}No	1911.00	1909.85	(0.28,5)
^{260}No	1923.22	1921.60	(0.27,0)
^{262}No	1934.87	1933.12	(0.26,0)
^{264}No	1946.47	1944.23	(0.25,0)

TABLE II: Alpha Decay Properties of No isotopes

Nuclei	Q_α (MeV)	$logT^{\alpha}_{1/2}$ UDL	$logT^{\alpha}_{1/2}$ UNIV2	$logT^{\alpha}_{1/2}$ Expt.
^{248}No	8.406	-1.917	0.806	-5.69
^{250}No	7.721	0.236	3.165	-5.38
^{252}No	8.136	-1.144	1.640	0.38
^{254}No	7.726	0.168	3.077	1.71
^{256}No	7.445	1.122	4.125	0.46
^{258}No	6.911	3.118	6.335	-2.92
^{260}No	6.475	4.930	8.352	0.97
^{262}No	6.132	6.485	10.08	-2.30
^{264}No	5.655	8.888	12.79	

gible. The calculated decay half-lives against ^{28}Mg decay are found to be significant and tabulated our results in Table III. The decay half-lives for first three isotopes are very small which suggest possibilities of decaying ^{28}Mg. Decay half-lives against α decay are larger than half-lives against cluster decay in the form of ^{28}Mg. The relatively shorter half-lives

Conclusion

From the present investigation of Q-values and the corresponding half-lives of alpha decay and cluster radioactivity, the predicted results with different formalisms are in reasonable good agreement among themselves but is

TABLE III: Cluster radioactivity of No isotopes in form of ^{28}Mg nucleus

Nuclei	Daughter Nucleus	Q_α (MeV)	$logT^{\alpha}_{1/2}$ UDL	$logT^{\alpha}_{1/2}$ UNIV2
^{248}No	^{28}Mg	114.06	-3.86	-0.82
^{250}No	^{28}Mg	110.51	-1.07	0.71
^{252}No	^{28}Mg	107.98	0.96	1.90
^{254}No	^{28}Mg	105.83	2.74	2.98
^{256}No	^{28}Mg	105.53	2.87	3.04
^{258}No	^{28}Mg	105.06	3.15	3.21
^{260}No	^{28}Mg	104.41	3.61	3.48
^{262}No	^{28}Mg	103.62	4.20	3.84
^{264}No	^{28}Mg	102.59	5.04	4.37

away from experimental data. This suggests the model as well as the model parameter dependence in the present study. Only UDL results are somehow closer to the experimental data for ^{252}No, ^{254}No, and ^{256} No in case of alpha-decay. In case of cluster radioactivity, probability of decay of clusters (like ^{8}Be, ^{12}C and ^{16}O) is very rare due to their longer half-life whereas ^{28}Mg cluster decay is dominated as it has shorter half life. Thus, these findings will provide opportunities for the future experimental researches.

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