Decay energy and Half-life values in Superheavy elements using Relativistic mean field model

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Introduction

Recent progress of Radioactive Ion Beam (RIB) facilities has encouraged various theoretical and experimental developments for nuclei far from β-stability line. The nuclear structure and decay mechanism in neutron rich nuclei is a very popular field of study in present days. We studied the ground and excited states properties of some superheavy elements starting from proton to neutron driplines using the relativistic mean- field formalism. The NL3 parameter set is used in the calculations. We find almost spherical ground and superdeformed excited states in most of the isotopes.

I. FORMALISM

The relativistic mean field (RMF) [1] Lagrangian with NL3 parameter set [2–4] contained interaction between meson and nucleon and also self interacting sigma meson. The other mesons are the omega and rho fields. The photon field A_μ is included to take care of Coulombic interaction of protons. A set of coupled equations are obtained from the Lagrangian, which are solved numerically in an axially deformed harmonic oscillator basis taking 16 bosonic and Fermionic oscillator quanta [5]. In this model pairing and center of mass correction are added externally [1].

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Result and Discussion

The Q_α energy is obtained from the relation [6]: $Q_\alpha(N,Z)$ $=BE(N,Z)$ -$BE(N-2,Z-2)$ -$BE(2,2)$.Here, $BE(N,Z)$ is the binding energy of the parent nucleus with neutron number N and proton number Z,$BE(2,2)$ is the binding energy of the α- particle(^{4}He),i.e.,28.296Mev,and $BE(N-2,Z-2)$ is the binding energy of the daughter nucleus after the emission of an α-particle.

With the Q_α energy at hand,we estimate the half-life time$T^{\alpha}_{1/2}$ by using the phenomenological formula of [7]: $log_{10}T^{ph}_{\alpha}(Z,N) = aZ[Q_\alpha(Z,N)-\overline{E_i}]^{-1/2}+bZ+c$. with Z as the atomic number of the parent nucleus.where the parameters a =1.5372,b =-0.1607,c =-36.573 and the parameter $\overline{E_i}$ (average excitation energy of the daughter nucleus) is,

$$\begin{aligned}\overline{E_i} &= 0 \quad \text{for } Z \text{ even} - N \text{ even}\\ &= 0.113 \quad \text{for } Z \text{ odd} - N \text{ even}\\ &= 0.171 \quad \text{for } Z \text{ even} - N \text{ odd}\\ &= 0.284 \quad \text{for } Z \text{ odd} - N \text{ odd.}\end{aligned} \tag{1}$$

The binding energy (BE), charge radius and quadrupole moment deformation parameter β_2 for Z =126-130 isotopes are obtained with RMF(NL3) formalism and depicted in Table. When we compare the ground state with all the excited state solutions, we get a well developed intrinsic excited superdeformed state in all the isotopes. In most of the cases of the considered isotopes, we get a spherical or a normal deformed solution both in RMF(NL3)

TABLE I: The RMF(NL3) results for binding energy BE,charge radius r_{ch}, quadrupole deformation parameter β_2, of some superheavy nuclei. The energy is in MeV and radius results are in fm.

	RMF(NL3)					
A	Z	BE	r_{ch}	β_2	Q_α	t_α
316	126	2177.10	7.45	0.007	15.03	$10^{-7.59}$
320	126	2209.86	7.68	0.433	06.63	$10^{18.60}$
330	126	2265.56	7.66	0.331	11.71	$10^{-0.69}$
334	126	2285.44	7.65	0.334	11.31	$10^{0.32}$
338	126	2304.55	7.62	0.336	10.50	$10^{3.46}$
322	128	2212.09	7.51	0.434	06.15	10^{20}
324	128	2227.39	7.51	0.542	10.77	$10^{2.41}$
326	128	2240.14	7.43	0.543	12.49	$10^{-2.01}$
328	128	2252.41	7.23	0.543	12.32	$10^{-1.64}$
320	130	2175.01	7.34	0.008	16.08	$10^{-8.46}$
324	130	2212.58	7.45	0.435	15.17	$10^{-6.93}$
326	130	2229.04	7.30	0.542	11.35	$10^{1.40}$
328	130	2242.44	7.45	0.543	13.24	$10^{-3.18}$

calculations, which can be seen from the Table. The interesting superdeformed solutions are obtained in an excited configuration for almost all the presently discussed isotopes. The binding energy increases with increase in mass number in the isotopic series. We have compared our calculated RMF results. We find both normal and superdeformed solutions of the above isotopes in the RMF frame-work. Also, we have evaluated the α- decay properties of some of these nuclei, which will be discussed at the time of presentation.

Conclusion

In summary, we have calculated the binding energy, charge radius, quadrupole deformation parameter of some Superheavy elements and their isotopes. We have calculated the various parameters of the above isotopes using Relativistic mean field theory. We have seen that the RMF theory provides a reasonably good description for the whole isotopic chain of spherical and super-deformed nuclei in the considered regions of the isotopic bands. The decay and other related properties will be discussed at the time of presentation.

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