STRUCTURAL AND DECAY PROPERTIES OF FRANCIUM ISOTOPES

S. Mahapatro[1],* M. Bhuyan[2],† S. K. Singh[2],‡ and S. K. Patra[2§]
[1] *Department of Physics, Spintronic Technology and Advanced Research, Bhubaneswar-752 050, India. and*
[2] *Institute of Physics, Sachivalaya Marg, Bhubaneswar-751 005, India.*

Introduction

The structure of the neutron-deficient Fr(Z=87) isotopes has attracted a lot of interest due to a multitude of phenomena occurring in these nuclei because of the vicinity to the closed proton shell at Z= 82. A systematic appearance of low-lying intruder states is among the most interesting phenomena in this region [1].

The studies of the odd-odd Fr nuclei are difficult as the coupling of odd valence neutron and odd valence proton results in multiple of states, both normal and intruder, some members of which can become isomeric [2]. In this respect α-decay often offers an ideal tool to identify the states in the daughter nucleus which have the same spin, parity, and configuration as in the α- decaying parent nucleus.

In the odd-odd mass nuclei, proton excitations across the Z= 82 shell gap give rise to isomerism, which can be investigated via α-decay, e.g. the Francium isotopes which disintegrate through the corresponding Astatine and Bismuth to Thallium nuclei. We have calculated the binding energies of the Francium isotope from ^{180}Fr to ^{240}Fr . Here we have taken the relativistic mean field (RMF) model Lagrangian [3] with NL3 parameter set [4] to find out the decay properties of Francium. This set is quite successful both in β- stable and drip line nuclei. The Lagrangian 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 equation are obtained from the Lagrangian, which are solved numerically in an axially deform harmonic oscillator basis taking 16 bosonic and Fermionic oscillator quanta [5]. In this model pairing and center of mass correction are added externally [3].

Result and Discussion

We have calculated binding energy(BE), charge radii(r_{ch}), quadrupole deformation parameter β_2, Two-neutron separation energy (S_{2n}), for Francium isotopes having mass from 180 to 240 using RMF formalism. The S_{2n} decreases with increase in neutron number. The binding energy increases with increase in mass number. We have compared our calculated RMF result with FRDM result. We found that there is a sharp fall in S_{2n} at $A = 196$ in RMF. In case of $^{196-198}Fr$-region, we get prolate in RMF but FRDM show oblate structure. The BE of RMF overestimate than finite range droplet model(FRDM) data.

Conclusion

In summary, we have calculated the binding energy, charge radii, quadrupole deformation parameter of the Francium (Fr) isotopes. We observed that the calculated values of RMF are in good agreement with the available FRDM data. We have seen that the RMF theory provides a reasonably good description for the whole isotopic chain. The decay and

*Electronic address: narayan@iopb.res.in
†Electronic address: bunuphy@iopb.res.in
‡Electronic address: shailesh@iopb.res.in
§Electronic address: patra@iopb.res.in

TABLE I: The RMF(NL3) results for binding energy BE, two-neutron separation energy S_{2n}, one-neutron separation energy S_n, quadrupole deformation parameter β_2, charge radius r_{ch}, neutron radiusr_n, proton radius r_p, compared with the corresponding Finite Range Droplet Model (FRDM) [6, 7] results. The energy is in MeV and radius results are in fm.

	RMF(NL3) Result								FRDM Result			
Nucleus	BE	r_{ch}	r_n	r_p	$r_n - r_p$	β_2	S_{2n}	S_n	BE	β_2	S_{2n}	S_n
^{192}Fr	1467.908	5.630	5.606	5.619	-0.013	0.422	21.905	10.938	1460.41	0.339	21.62	9.93
^{193}Fr	1478.503	5.648	5.617	5.634	-0.017	0.427	21.533	10.595	1471.59	0.359	21.12	11.19
^{194}Fr	1488.832	5.558	5.493	5.529	-0.036	0.202	20.924	10.329	1480.88	0.283	20.48	9.29
^{195}Fr	1500.535	5.586	5.521	5.557	-0.036	-0.226	22.032	11.703	1491.93	0.359	20.34	11.05
^{196}Fr	1509.452	5.579	5.498	5.543	-0.045	0.187	20.62	8.917	1500.91	-0.257	20.03	8.98
^{197}Fr	1519.465	5.590	5.501	5.551	-0.050	0.180	18.93	10.013	1511.84	-0.249	19.91	10.93
^{198}Fr	1529.260	5.601	5.504	5.559	-0.055	0.172	19.808	9.795	1521.03	-0.249	20.11	9.18

other related properties will be discussed at the time of presentation.

References

[1] K. Heyde et. al, *Phys. Rep.* **102**, (1983) 291.

[2] A. J. Kreiner et. al, *Phys. Rev. Lett* **47**, (1981) 1709.

[3] J. Boguta and A. R. Bodmer, *Nucl. Phys. A* **292** (1977) 413.

[4] G. A. Lalazissis, J. Konig and P. Ring, *Phys. Rev. C* **55** (1997) 1.

[5] W. Pannet, P. Ring and J. Boguta, *Phys.Rev. Lett.* **59** (1987) 21.

[6] P. Möller, J. R. Nix, and K. -L. Kratz, *Atomic and Nucl. Data Tables* **59** (1995) 185.

[7] P. Möller, J. R. Nix and K. -L. Kratz, *Atomic and Nucl. Data Tables* **66** (1997) 131.