Study of even-even Curium isotopes

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Introduction

Spectroscopic data on nuclei with atomic number in the neighbourhood of Z≈100 gives one an opportunity of carring out systematic studies on some new features of nuclear structure [1,2]. In this regard, it is important to mention that nuclear structure data has become available on some even-even Cm isotopes wherein, it has become possible to map energy spectra up to high spins [3,4,5,6]. Besides, experimental data has also become available for electromagnetic properties of some of the Cm isotopes [7]. Ishii et al [3] have measured the de-excitation of gamma rays of the heaviest neutron-rich ^{250}Cm and they have obtained the level energy of the ground state bands up to spin I= 12ħ in ^{250}Cm. Ahmad et al [4] have pointed out the existence of ground state rotational bands with identical transition energies up to spin I= 8ħ in ^{244}Cm and ^{246}Cm. Microscopic study of the yrast line in the well deformed actinide nuclei have been performed by Egido and Ring [8]. Several versions of cranking model have been discussed by these authors. They have found that the mean–field approach, in the form of cranking model in the simplified version of the rotating shell model is able to reproduce the alignment and band crossing pattern at the yrast line.

Recently Zhang et al [9] have carried out a systematic study of the single particle structure and rotational properties of nuclei with Z≈100 by employing cranked shell model with pairing correlations treated by particle-number conserving method. They obtained a new set of Nilsson parameters (κ and μ) by fitting the experimental single-particle levels in the Z≈ 100 region In the present work, the yrast bands and B(E2) transition probabilities of even-even Cm isotopes have been studied by using Projected shell model (PSM) approach. The results are reproduced by taking the same set of Nilsson parameters obtained by Zhang et al [9] in the Z≈100 mass region.

Brief Description of Theoretical Framework

The PSM [10] is a kind of shell model approach. However, unlike the conventional shell model, the PSM begins with the deformed Nilsson type single particle basis. The Hamiltonian which has been used in the present work is described as follows.

$$\hat{H} = \hat{H}_0 - \frac{1}{2}\chi\sum_{\mu}\hat{Q}^{\dagger}_{\mu}\hat{Q}_{\mu} - G_M\hat{P}^{\dagger}\hat{P} - G_Q\sum_{\mu}\hat{P}^{\dagger}_{\mu}\hat{P}_{\mu}$$

where H_0 is the spherical single particle Hamiltonian which contains a proper spin-orbit force. The quadrupole quadrupole interaction strength χ is determined by the self-consistent relation with deformation parameter. The single particle space consists of three major shells N=4, 5, 6 for protons and N=5, 6, 7 for neutrons. The strength of the monopole pairing force is given by

$$G_M = \left[G_1 \mp G_2\frac{N-Z}{A}\right]A^{-1}$$

with '–' for neutrons and '+' for protons.

Results and Discussion

The quadrupole and hexadecapole deformation parameters used in the present calculation are listed in Table 1. In Fig.1, a comparison of calculated and experimental yrast energies of $^{242\text{-}250}$Cm isotopes are presented. The experimental level scheme of yrast bands for $^{242\text{-}250}$Cm [3,4,5,6] isotopes are available up to spins 26^+, 8^+, 26^+, 30^+, 12^+, respectively. It is seen from figure 1 that the PSM calculation reproduces the available yrast energy levels up to known spins qualitatively. In Table 2, a comparison of experimental and calculated B(E2) values are presented. The experimental B(E2) values of ^{244,246}Cm are reproduced by taking an effective charge of 0.7 whereas for ^{248}Cm the experimental value is reproduced by taking an effective charge is 0.6.

Table 1: Quadrupole and hexadecupole deformation parameters used in the present calculations for $^{242\text{-}250}$Cm

Cm	242	244	246	248	250
ε_2	0.239	0.240	0.242	0.240	0.232
ε_4	0.030	0.040	0.040	0.015	0.018

Table 2: Comparison of experimental and calculated B(E2) transition probabilities in $^{242\text{-}250}$Cm isotopes. Experimental data is taken from ref. [7]

Nucleus	B(E2) (e^2b^2)			
	Exp.	Th.		
		e_{eff}=0.5	e_{eff}=0.6	e_{eff}=0.7
^{242}Cm	-	2.314	2.572	3.129
^{244}Cm	2.916(38)	2.296	2.549	3.094
^{246}Cm	2.988(38)	2.309	2.561	3.106
^{248}Cm	2.74(16)	2.575	2.862	3.481
^{250}Cm	-	2.334	2.592	3.148

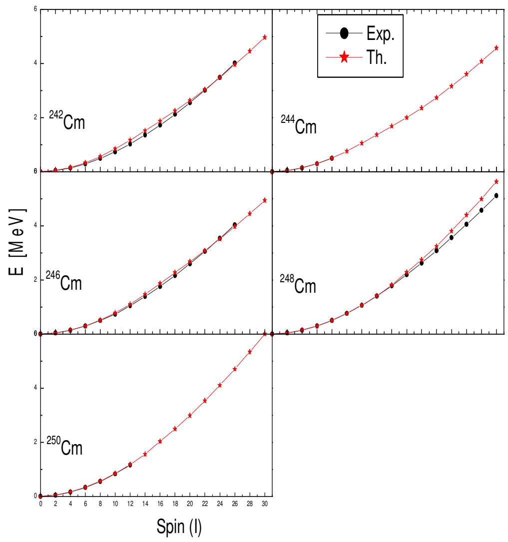

Fig. 1 Comparison of calculated (Th.) and experimental (Exp.) yrast energy of even-even $^{242\text{-}250}$Cm isotopes. The experimental data is taken from refs. [3,4,5,6]

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