A search for Hyper-deformed minimum in the *Am* isotopes

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Introduction

The nuclear fission is one of the most complex nuclear phenomena in nature and many aspects remain only partially understood even now [1, 2]. The most exciting development in the 70's was the idea of existence of a second well. This was supported by many calculations and later on led to the discovery of fission isomers. The phenomena of super-deformation predicted and observed in the 90's also relates to the second well, although at high spin. It is now well established that the second well relates to the formation of deformed shell gaps at the axes ratio of about 2:1. However, the existence of a third well corresponding to the shell gaps around 3:1 axes ratio has not been followed by similar spectacular discoveries. The third minimum has been discussed in the literature for many nuclides like thorium isotopes [3]. The search for third well should then be started to understand hyper deformed shapes of the nuclei with the axes ratio 3:1. The microscopic-macroscopic (mic-mac) approach is generally used to calculate the potential energy surfaces and analyze the potential barrier in the actinides. The smooth macroscopic part of the barrier is governed by Liquid drop energy and the microscopic correction is given by the Strutinsky shell correction method [4]. We explore the occurrence of the second/third well by using a similar calculation. Because of the experimental difficulties, the observation of the third well is a very difficult task; yet it may now be attempted with the availability of modern detector arrays and separators.

Formalism

In this paper, the mic-mac approach with Cassini Ovaloid Shape parameterization for the nuclear potential [5] has been utilized to calculate the potential energy surfaces. This formalism is due to Garcia et al [6]. The single particle energies as a function of deformation parameters are calculated from an axially deformed Woods-Saxon potential which is further used to calculate the shell and pairing corrections in the Strutinsky approach. Our aim is to search for the triple-humped fission barrier which may support the existence of hyper deformed isomers. We look for such a hyper deformed isomer near the magic numbers predicted around the 3:1 shapes [7].

It is well known that the harmonic oscillator magic numbers are upwardly modified to 2, 8, 20, 28, 50, 82, and 126 due to the spin-orbit term. For the anisotropic-oscillator, the deformed magic numbers for the axis ratio 2:1 (deformation=0.6) are 2, 4, 10, 16, 28, 40, 60, 80, 110, 140 and 182, which are also upwardly modified as recently shown for the super deformed nuclei [8]. As we go to the higher deformation at 0.86 with axis ratio 3:1, the numbers become 2, 4, 6, 12, 18, 24, 36, 48, 60, 80, 100, 120, 150, 180, and 210. See Fig. 1. The spin-orbit interaction will modify these numbers upwards. Therefore, we focus our search for the third well near those magic numbers which lie in the actinide region.

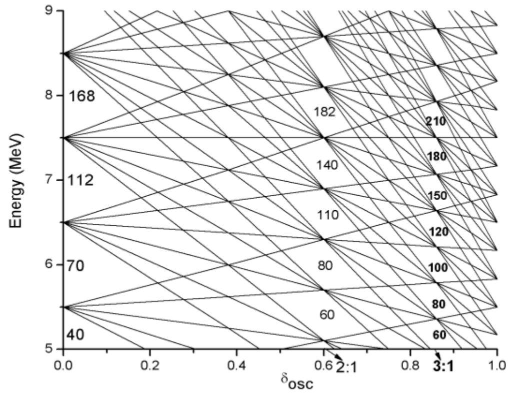

Fig. 1 Anisotropic-harmonic oscillator energy scheme with shell gaps at 2:1 and 3:1 axis ratio respectively.

Results and Discussion

We have calculated the potential energy surfaces for the nuclei having Z = 93 to 96 and N ~ 150 for the search of triple-hump barrier. The second well is prominently visible at a deformation around 0.5 throughout this region. Our calculations show that the third well corresponding to the 3:1 shell structure begins to appear in the deformation range 0.7-0.8 near neutron number 150 and above. We show the results only for Z=93 and 95 isotopes in fig. 2 and 3.

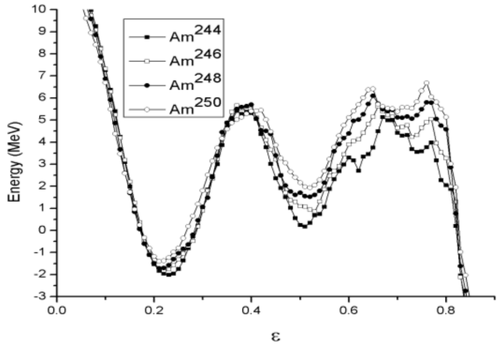

Fig. 2(a) Potential barrier for Z=95 even-A *Am* isotopes.

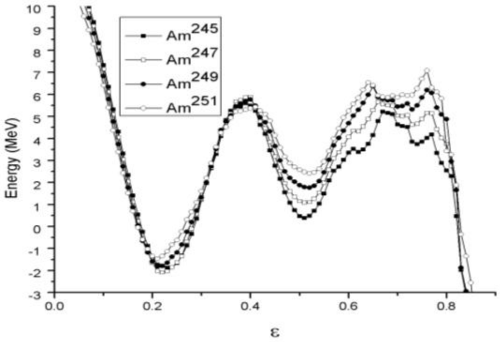

Fig. 2(b) Potential barrier for Z=95 odd-A *Am* isotopes.

The outer barrier decreases as we go from Z=93 to 95 due to increasing Coulomb energy contribution to the barrier. It starts to be more flat and leads to the existence of the deeper third well in the neutron-rich side of the particular isotopic chain. These plots show that the *Am* nuclides may be the best candidates for third minimum. The deepest third minimum is observed in ^{250}Am with a depth of 1.29 MeV. The next possible candidate is ^{251}Am. However, the experimentally accessible isotopes may be $^{244,245}Am$. These nuclides have sufficiently deep minimum to observe hyper deformed isomer. However, further calculations are in progress to establish this.

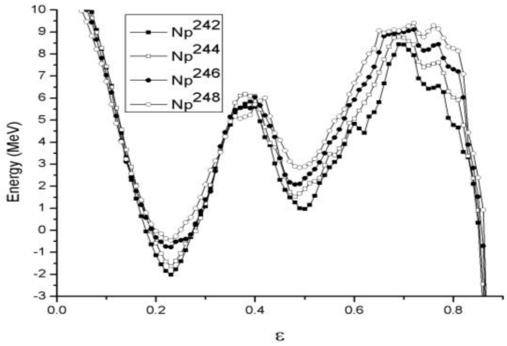

Fig. 3(a) Potential barrier for Z=93 even-A *Np* isotopes.

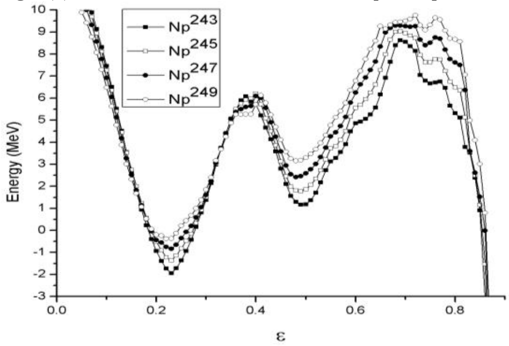

Fig. 3(b) Potential barrier for Z=93 odd-A *Np* isotopes.

Financial support from MHRD (Govt. of India) to BM is acknowledged.

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