Rotational Structures of Neutron Deficient Isotopes ^{125,127,129}Ce*

MA Hai-Liang[1)] DONG Bao-Guo

(China Institute of Atomic Energy, Beijing 102413, China)

Abstract The configuration-dependent cranked Nilsson-Strutinsky approach has been used to investigate rotational structures of neutron deficient isotopes ^{125,127,129}Ce. Signature splitting and deformation of yrast bands have been discussed. Shape coexistence may exist in ^{127,129}Ce. The signature splitting of yrast bands for Ce isotopes is strongly dependent on occupied orbitals because of slight triaxial deformation.

Key words signature splitting, shape coexistence, triaxial deformation

1 Introduction

^{125,127,129}Ce isotopes have been populated experimentally to high spin states in past decades[1—4]. These isotopes are well deformed with quadrupole deformation of $\beta_2 = 0.25 - 0.30$[5]. In present paper, level schemes, shape coexistence and signature splitting have been studied in the framework of configuration-dependent cranked Nilsson-Strutinsky (CNS) approach[6, 7]. The Nilsson parameters are quoted from Ref. [6] and pairing correlations neglected, so it is qualitatively to compare the calculated bands with observed bands in the low spin region $I < 15\hbar$. In the high spin region, where pairing correlation will play less important role or is negligible, the discrepancy between experimental results and cranked shell model calculations will become small[8].

In the following a short notation will be used to label the configurations(relative to $^{100}\mathrm{Sn}_{50}$ core), $[\mathrm{p,n}] \equiv \pi(h_{11/2})^{\mathrm{p}} \otimes \nu(h_{11/2})^{\mathrm{n}}$. The simplification for signature is used: $(\alpha = +) \equiv (\alpha = +1/2)$ and $(\alpha = -) \equiv (\alpha = -1/2)$. Then we have four combinations of parity and signature indicated by (π, α).

The experimental and theoretical $E - E_{\mathrm{RLD}}$ energies as a function of spin are shown in Fig. 1, where $E_{\mathrm{RLD}} \equiv (\hbar^2/2J_{\mathrm{rig}})I(I+1) \equiv 32.32A^{-5/3}I(I+1)$ MeV is the energy of a rigid rotor reference with A being the mass number. Here we only show the configurations near yrast line and left panels for $\pi = +$ and right panels $\pi = -$. In the figure, the experimental and theoretical $E - E_{\mathrm{RLD}}$ values have been renormalized at the highest spin state for both parities.

2 Signature splitting

Based on the CNS calculations, the [2,7] configuration is assigned to the negative parity yrast bands. It is the same as previous works[1—4]. For the positive parity yrast bands, its configuration is assigned as [2,6] for ^{125}Ce and [2,8] for ^{129}Ce. For positive parity band of ^{127}Ce, it was observed only up to $25/2\hbar$, so we do not show experimental result in Fig. 1.

Signature splitting is the energy shift between energetically favored and unfavored bands. The energy staggerings of the calculated [2,6] configuration and the observed band 3 in ^{125}Ce are shown in Fig. 2. Here we use the same definition as in Ref. [9],

$$\Delta E(I) = E(I) - E(I-1) - \frac{E(I+1) - E(I) + E(I-1) - E(I-2)}{2}.$$

* Supported by National Natural Science Foundation of China (10275093)
1) E-mail: mhl624@iris.ciae.ac.cn

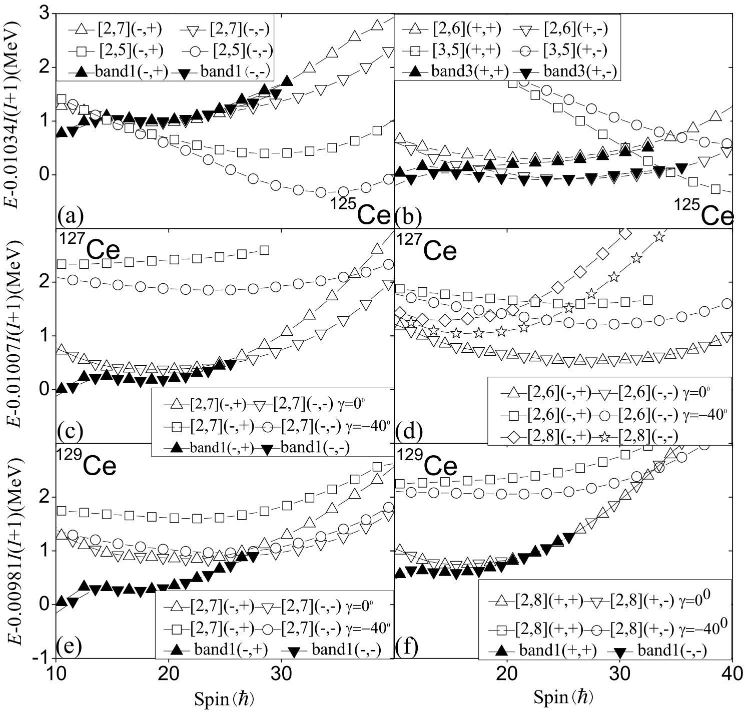

Fig. 1. Energies as a function of spin for the calculated and observed bands of interest for ^{125,127,129}Ce. The open symbols indicate the calculated data and the solid ones the observed data.

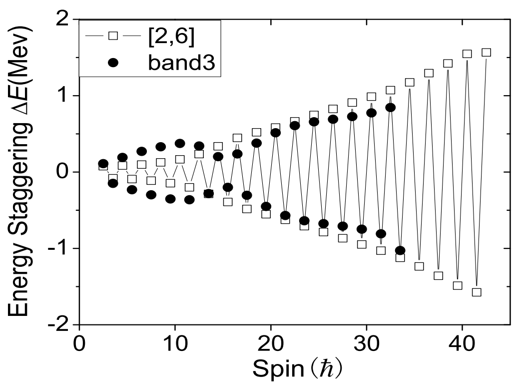

Fig. 2. Energy staggerings $\Delta E(I)$ plotted versus spin for the calculated [2,6] configuration and observed band 3 in ^{125}Ce.

The calculated shape trajectories as a function of spin corresponding to the calculated yrast bands are shown in Fig. 3. It can be seen from Fig. 3 that the deformation of configuration [2,6] is near axial. So even if no triaxial deformation, large signature splitting still can exist.

For ^{127,129}Ce, very small signature splitting will be expected for the yrast bands since it can be seen in Fig. 1 that the calculated and observed signature partner bands are nearly degenerated. It is confirmed that the CNS approach reproduces signature splittings well in the high spin region.

3 Nuclear shapes

In Ref. [10], the γ driving force of odd-odd Pr isotopes has been studied. Since ^{125,127,129}Ce isotopes have the same neutron number as ^{126,128,130}Pr, the γ driving force is similar. In our CNS calculations, all yrast bands show very small values of triaxial deformation, $\gamma\sim0°$, except the negative parity configuration [2,7] of ^{125}Ce. The calculated potential energy surfaces (PES) for this negative parity [2,7] configuration in ^{125}Ce show that this configuration is very γ-soft.

There are shape coexistences within the same configuration in ^{127,129}Ce which means there are two minima in the PES. One is located at around $\gamma\sim0°$ and the other is located at around $\gamma\sim-40°$. Both bands built on the two minima are shown in Fig. 1. The $\gamma\sim-40°$ bands are higher in energy than the $\gamma\sim0°$ bands, the favored bands, in the interesting spin region. According to this band structures, observed yrast bands only have slight triaxial deformation in ^{127,129}Ce.

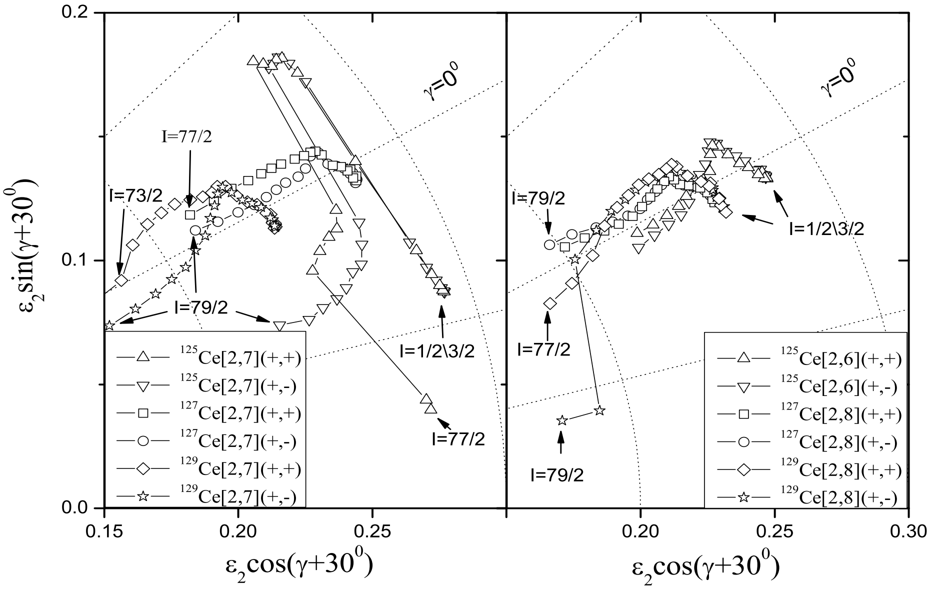

Fig. 3.　Calculated shape trajectories of the yrast configurations as a function of spin in the (ε_2, γ)-plane for ^{125,127,129}Ce.

4　Conclusions

The band structures, nuclear shape and signature splitting of neutron deficient odd-even cerium isotopes ^{125,127,129}Ce have been investigated in the framework of CNS approach. The triaxial deformation of yrast bands in ^{125,127,129}Ce is small, $\gamma \sim 0°$. There is shape coexistence in ^{127,129}Ce within the same configuration. Even no triaxial deformation, large signature splitting can exist. Good agreement is found between theoretical and experimental results when spin is over $15\hbar$ for these Ce isotopes.

References

1　Smith J F et al. Phys. Rev., 2004, **C69**: 034339
2　Petrache C M et al. Eur. Phys. J., 2002, **A14**: 439
3　Nyako B M et al. Z. Phys., 1989, **A334**: 513
4　Galindo-Uribarri A et al. Phys. Rev., 1996, **C54**: R454
5　Zeidan O et al. Phys. Rev., 2002, **C65**: 024303
6　Bengtsson T, Ragnarsson I. Nucl. Phys., 1985, **A436**: 14
7　Afanasjev A V, Ragnarsson I. Nucl. Phys., 1995, **A591**: 387
8　Afanasjev A V et al. Phys. Rep., 1999, **322**: 1
9　Hartley D J et al. Phys. Rev., 2000, **C61**: 044328
10　Dong B G et al. Phys. Rev., 2006, **C74**: 014308

缺中子核素^{125,127,129}Ce的转动结构*

马海亮[1)]　董保国

(中国原子能科学研究院　北京　102413)

摘要　用组态相关推转Nilsson-Strutinsky方法研究了缺中子核素^{125,127,129}Ce的转动结构性质, 讨论了转晕带的旋称劈裂和核的形状. 转晕带相应的核形状均是近轴对称的. ^{127,129}Ce在同一个组态中可能有形状共存. 理论指出即使对于无三轴形变核也有可能出现较大的旋称劈裂.

关键词　旋称劈裂　形状共存　三轴形变

＊国家自然科学基金(10275093)资助

1) E-mail: mhl624@iris.ciae.ac.cn