CPC(HEP & NP), 2009, **33**(Suppl. I): 212—214 **Chinese Physics C** Vol. 33, Suppl. I, Mar., 2009

Signature splitting in ^{129}Ce*

LIU Ying(刘颖)[1] WU Xiao-Guang(吴晓光)[1] ZHU Li-Hua(竺礼华)[1,5;1)] LI Guang-Sheng(李广生)[1]
HE Chuang-Ye(贺创业)[1] LI Xue-Qin(李雪琴)[1] PAN Bo(潘波)[1] HAO Xin(郝昕)[1]
LI Li-Hua(李立华)[1] WANG Zhi-Min(王治民)[1] LI Zhong-Yu(李忠宇)[2] XU Qiang(徐强)[3]

1 (China Institute of Atomic Energy, Beijing 102413, China)
2 (Peking University, Beijing 100871, China)
3 (Tsinghua University, Beijing 100084, China)
4 (Jilin University, Changchun 130012, China)
5 (Faculty of Science, Shenzhen University, Shenzhen 518060, China)

Abstract The high spin states of ^{129}Ce have been populated via heavy-ion fusion evaporation reaction ^{96}Mo (^{37}Cl, 1p3n) ^{129}Ce. The γ-γ coincidence and intensity balance used to measure the $B(\mathrm{M1}; I \rightarrow I-1)/B(\mathrm{E2}; I \rightarrow I-2)$ (the probability ratio of the dipole and quadrupole transition) in $\nu 7/2[523]$ rotational band of ^{129}Ce. And the energy splitting ($\Delta e'$) has been got through the experimental Routhians. The lifetimes and quadrupole moments Q_t have been extracted from the lineshape analyses using DSAM. The deformation of the $\nu 7/2[523]$ rotational band of ^{129}Ce was extracted from the Q_t and moment of inertia J_{RR}.

Key words triaxiality, lifetime measurement, signature splitting

PACS 21.10.Tg, 27.60.+j, 25.70.Jj

1 Introduction

Signature splitting and inversion have been observed in the nuclei with $A \sim 80$, 100, 130 and 160. As one of the explanations to the signature splitting and inversion, triaxial deformation is closely related to triaxial super deformation, Magnetic Rotation and Chiral Rotation. Theoretical arithmetic has been done for triaxial deformation, but no experimental proof. In the present work, the lifetimes and quadrupole moments Q_t of the $\nu\ 7/2^{-}[523]$ band of ^{129}Ce have been determined, and an evidence for the signature splitting resulted from γ deformation is provided.

2 Experiment

The experiment was carried out in the HI-13 tandem accelerator at the China Institute of Atomic Energy. The high spin states of ^{129}Ce have been populated via heavy-ion fusion evaporation reaction ^{96}Mo (^{37}Cl,1p3n)^{129}Ce. The beam energy was 155 MeV and the target was of thickness 1.0 mg/cm^2, mounted on a 19 mg/cm^2 Pb backing. The γ-rays from the evaporated residues were detected with an array consisting of fifteen Compton suppressed HPGe-BGO spectrometers. A total of about 2.46×10^8 γ-γ coincidence events were collected.

3 Data and results

The lifetimes and quadrupole moments Q_t have been extracted from the line shape analyses using DSAM (shown in Table 1). It is concluded that the average value of Q_t is about 4.127 eb after backbending. Fig. 1 shows fitted line shapes for the 579 keV and 739 keV transitions in ^{129}Ce. Both display the backward angle spectra. The solid line display the total fitted line shape.

At very high spin and for member states of a rotational band the quadrupole transition moments depend only on the deformation parameters β and γ as[1]

Received 3 September 2008

* Supported by Major State Basic Research Development Program (2007CB815000) and National Natural Science Foundation of China (10775184, 10575092, 10675171, 10375092, 10575133)

1) E-mail: zhulh@ciae.ac.cn

$$Q_t = 3\sqrt{\frac{1}{5\pi}} ZeR_0^2\beta\cos(30^\circ+\gamma)/\cos 30^\circ \ , \qquad (1)$$

with the nuclear charge Z and the mean nuclear radius R_0, which is assumed to have a mass dependence of $R_0 = 1.2A^{1/3}$.

Table 1. Lifetimes and quadrupole moments Q_t in the negative band of ^{129}Ce.

spin	$E\gamma$/keV	Q_t/eb	τ/ps
$21/2^-$	722	6.503(91)	0.295(80)
$23/2^-$	727	3.984(1394)	0.875(495)
$25/2^-$	756	3.570(108)	0.482(32)
$27/2^-$	739	2.942(642)	1.282(416)
$29/2^-$	542	5.080(503)	1.651(382)
$31/2^-$	571	4.592(912)	1.127(395)
$33/2^-$	579	6.301(1907)	0.427(348)
$35/2^-$	655	4.703(1477)	0.474(365)
$37/2^-$	718	>3.551	<0.480
$39/2^-$	793	>3.209	<0.405

Deformation should also be reflected in a variation of the collective moments of inertia, which depend on the quadrupole deformation parameters β and γ as

$$J_{\rm RR} = \frac{2}{5}MR_0^2\left(1+\sqrt{\frac{4}{5\pi}}\beta\sin(30^\circ+\gamma)\right). \qquad (2)$$

With, M stands for the mass of the nucleus, and $J_{\rm RR}$ rigid-rotor moments of inertia the momentum of inertia of the system.

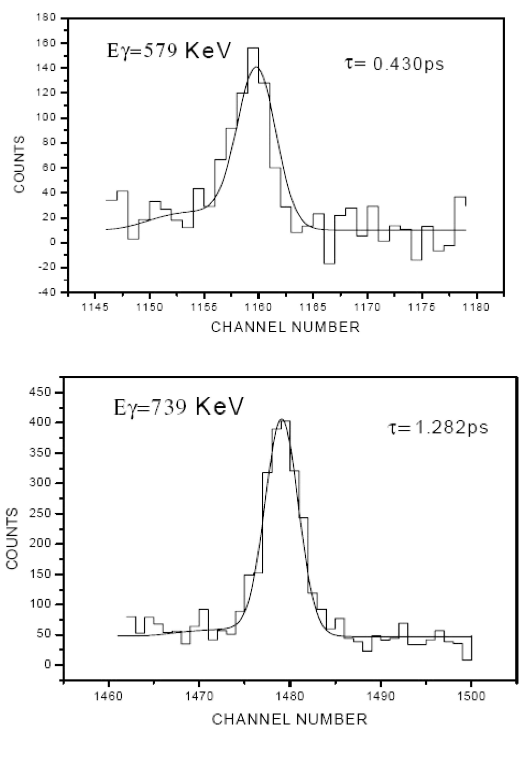

Fig. 1. Fitted line shapes for the 579 keV and 739 keV transitions in ^{129}Ce.

Where $J_{\rm RR}$ can been obtained from the experimental transition energies and spins. The average value of $J_{\rm RR}$ is 50.7 MeV$^{-1}\hbar^2$ after the backbending. The deformation of the negative band of ^{129}Ce was extracted through the simultaneous solution of equations for Q_t and $J_{\rm RR}$. It is concluded that the γ deformation is about 0 degree and β is 0.27 after the backbending with $J_{\rm RR} = 50.7$ MeV$^{-1}\hbar^2$ and $Q_t =$ 4.127 eb.

On the other side, the γ-γ coincidence and intensity balance used to measure the $B({\rm M1}; I\to I-1)/B({\rm E2}; I\to I-2)$ (the probability ratio of the dipole and quadrupole transition) in ν 7/2[523] rotational band of ^{129}Ce. And the energy splitting ($\Delta e'$) has been got through the experimental Routhians. Using expressions of the relation between signature splitting of B(M1) and energy splitting ($\Delta e'$) presented by Hagemann and Hamamoto[2], we can determined on the magnitude of γ deformation. The relations of them are shown in Fig. 2 and Fig. 3.

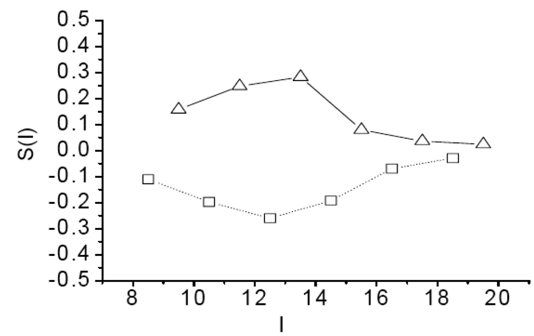

Fig. 2. Signature splitting in $\nu 7/2^-[523]$ band. □, $\alpha=-1/2$; △, $\alpha=+1/2$, $S(I) = E(I) - E(I-1) - [E(I+1) - E(I) + E(I) - E(I-2)]/2$.

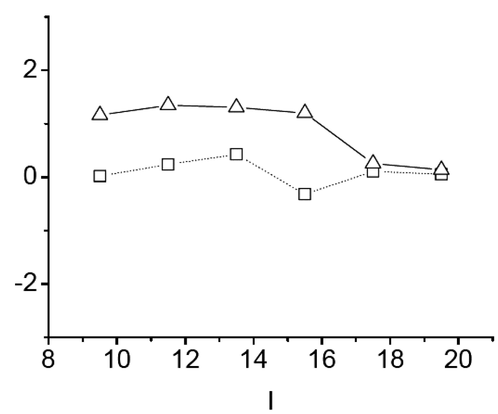

Fig. 3. The relation between signature splitting of B(M1) and energy splitting ($\Delta e'$). □, signature splitting of B(M1): $\dfrac{\Delta B({\rm M1}; I\to I-1)}{\langle B({\rm M1}; I\to I-1)\rangle}$; △, energy splitting ($\Delta e'$): $\dfrac{4(\Delta e'/\hbar\omega)}{1+(\Delta e'/\hbar\omega)^2}$.

The two figures show that while the signature splitting are decreasing closed to zero, its energy splitting ($\Delta e'$) are gradually equal to the signature splitting. The γ deformation became to zero from negative determined on the method given by Hagemann and Hamamoto.

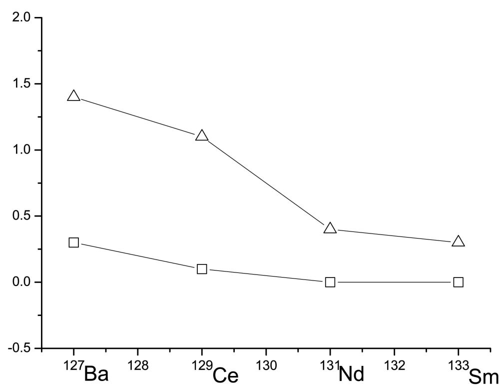

Fig. 4. The relation between signature splitting of B(M1) and energy splitting ($\Delta e'$) before backbending. □, signature splitting of B(M1): $\frac{\Delta B(\mathrm{M1}; I \rightarrow I-1)}{\langle B(\mathrm{M1}; I \rightarrow I-1)\rangle}$; △, energy splitting ($\Delta e'$): $\frac{4(\Delta e'/\hbar\omega)}{1+(\Delta e'/\hbar\omega)^2}$.

In ^{129}Ce, the negative-parity bands arise from an $h_{11/2}$ neutron on the [523]7/2 Nilsson orbital. The signature splittings in the bands are discussed in terms of the cranked shell model[3]. It is indicated that the three-quasiparticle bands including two $h_{11/2}$ quasiprotons have $\gamma \sim 0$ deformation after the band crossing. It is consistent with the result of our work. We propose that the signature splitting in $\nu 7/2^{-}[523]$ rotational band of ^{129}Ce arises from the γ deformation.

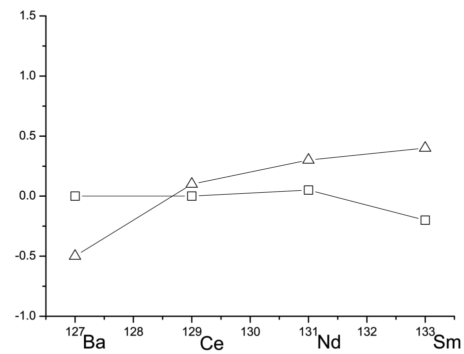

Fig. 5. The relation between signature splitting of B(M1) and energy splitting ($\Delta e'$) after backbending. □, signature splitting of B(M1): $\frac{\Delta B(\mathrm{M1}; I \rightarrow I-1)}{\langle B(\mathrm{M1}; I \rightarrow I-1)\rangle}$; △, energy splitting ($\Delta e'$): $\frac{4(\Delta e'/\hbar\omega)}{1+(\Delta e'/\hbar\omega)^2}$.

The isotones of ^{129}Ce are discussed in the relation between signature splitting of B(M1) and energy splitting ($\Delta e'$). The relation of them are showed in Fig. 4 and Fig. 5. In the Fig. 4, the isotones have negative γ deformation before backbending. And the value of γ tends to zero with the protons increasing. While as the Fig. 5 shown, the value of γ deformation is changed from zero to negative after backbending.

References

1 Price H G et al. Phys. Rev. Letts., 1983, **51**: 1842
2 Hagemann G B et al. Phys. Rev. C, 1989, **40**: 2862
3 Aryaeinejad R et al. J. Phys. G: Nucl. Phys., 1984, 10