Eur. Phys. J. A **3**, 99–101 (1998)

THE EUROPEAN PHYSICAL JOURNAL A

Short note

In-beam spectroscopy of ^{126}Ce and ^{127}Pr

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Received: 16 June 1998
Communicated by B. Herskind

Abstract. High spin states in ^{126}Ce and ^{127}Pr were populated *via* heavy ion reactions with 182-MeV ^{35}Cl projectiles on a thick ^{96}Ru target. Prompt γ–γ coincidences were measured. New states in ^{126}Ce and ^{127}Pr were found. The results are discussed in the framework of the core–quasiparticle coupling model.

PACS. 21.10.Re Collective levels – 21.60.En Angular distribution and correlation measurements – 23.20.Lv Gamma transitions and level energies – 27.60.+j $90 \leq A \leq 149$

The present investigation of the ^{126}Ce and ^{127}Pr nuclei is a continuation of our studies of neutron deficient nuclei [1] from the mass A ∼ 130 region. Excited states in ^{126}Ce and ^{127}Pr were populated through the ^{96}Ru(^{35}Cl,3p2n) and ^{96}Ru(^{35}Cl,2p2n) reactions, respectively. A 182 MeV ^{35}Cl beam was produced by the HI LINAC at SUNY - Stony Brook. A 2.5 mg/cm^2 thick ^{96}Ru target backed with Ta was used.

An array consisting of 6 Compton-suppressed Ge detectors and a 14 element BGO multiplicity filter was used to collect coincident γ-rays. The multipolarities of the γ transitions were deduced from angular correlation (DCO) ratios.

The ^{126}Ce nucleus was previously studied by Moscrop et al. [2]. From the present experiment, an extended level scheme of ^{126}Ce, as shown in Fig. 1, has been extracted. The yrast band up to I=18$^+$ is in full agreement with [2]. The side band from Ref. [2] is substantially modified in the current study: (1) new E2 transitions were added, a 317 keV transition to the bottom and 688 keV, 766 keV, 833 keV, and 896 keV tranisitons on the top of the band; and (2) decay paths were established through the 315 keV, 573 keV and 866 keV ΔI=1 transitions to the ground state band (gsb). A spin of 7 $\hbar$ is implied for the lowest observed state of the side band since no transition connecting this state to the 4$^+$ yrast state was observed. Negative parity is suggested since the decay paths of the band are similiar to those of the K=5 bands in neighbouring nuclei. In the present study, a second side band decaying through the 1193 keV and 1357 keV transitions to 6$^+$ and 4$^+$ levels of the gsb was observed for the first time. Tentative spin-parity assignments are suggested on the basis of the systematics of the 4$^-$ levels in neighbouring nuclei. A new

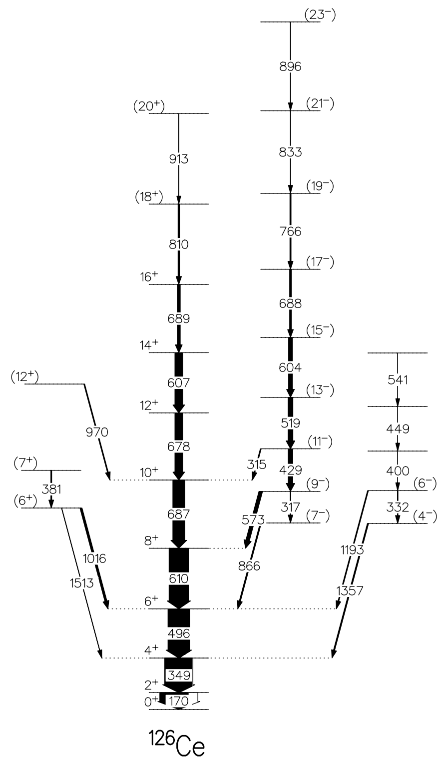

Fig. 1. Proposed level scheme of ^{126}Ce

level, for which we propose a 6$^+$ assignment, decays by the 1016 keV transition to the 6$^+$ state and the 1513 keV transition to 4$^+$ state of the gsb. Since the 381 keV feeding transition has a dipole character, a spin-parity assignment

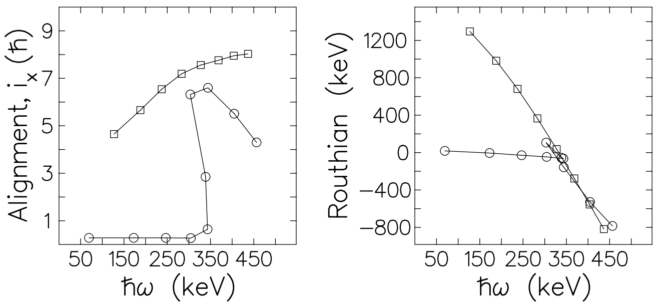

Fig. 2. Experimental aligned angular momenta and routhians for ^{126}Ce. ○ - yrast band, □ - K=5 band

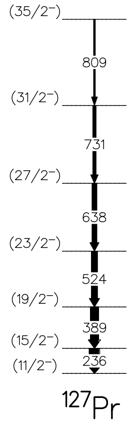

Fig. 3. Proposed level scheme of ^{127}Pr

of 7^+ is suggested for the level above. A new transition of 970 keV with a DCO ratio consistent with an E2 multipolarity was observed to feed the 10^+ state, suggesting a 12^+ level.

Experimental Routhians and aligned angular momenta extracted for the observed bands in ^{126}Ce are shown in Fig. 2 as a function of rotational frequencies. A K-value of 5 is assumed for the side band. Harris parameters of J_0= 16MeV$^{-1}\hbar^2$ and J_1=83 MeV$^{-3}\hbar^4$ were chosen for the reference which gives nearly constant alignment for the low-spin part of the yrast band. The yrast band shows a band crossing around $\hbar\omega$=320 keV with an alignment of about i=6.5 $\hbar$.This crossing has been assigned to an $h_{11/2}$ proton pair.

The three γ-rays (237, 390, 639 keV) assigned to ^{127}Pr have been observed by James et al. [3] using the Daresbury recoil separator. The level scheme inferred from the present study is shown in Fig. 3. The DCO ratios of the band transitions are consistent with stretched E2 multipolarities. This observed band in ^{127}Pr is expected to be the yrast $h_{11/2}$ proton band as seen in ^{125}La [1]. The sharp $h_{11/2}$ proton alignment observed in the ^{126}Ce yrast band is blocked by the odd $h_{11/2}$ proton for this ^{127}Pr band.

The negative parity states in ^{127}Pr are discussed in the framework of the core-quasiparticle coupling model (CQPC) [4]. In this model, an odd-A nucleus is treated as an odd quasiparticle (in our case proton) coupled to the (A-1) and (A+1) even-even cores. Our calculations for ^{127}Pr are very similiar to those presented in Refs. [5, 6], where more details and references are given.

In the case of ^{127}Pr, the (A-1) and (A+1) cores should be ^{126}Ce and ^{128}Nd, respectively. For simplicity we have assumed that both the (A-1) and (A+1)cores have properties of the ^{126}Ce nuclei. Our calculations justify this assumption since the states in which the particle is coupled to the ^{126}Ce core are strongly dominant in the wave function of the negative parity levels in ^{127}Pr. The ^{126}Ce core nucleus was described in the framework of the Davydov-Filippov model. The model parameters were chosen to reproduce the experimental data [2,7]. Satisfactory agreement was obtained (Fig. 4) with the following parameters: β=0.29, γ=16°, $E(2_1{}^+)$=160 keV.

For the ^{127}Pr calculation, the proton single particle energy and the strength of the core-quasiparticle coupling were taken from [5]. The position of the Fermi level (λ-$\epsilon(h_{11/2})$)= 2.23 MeV was chosen to reproduce the number of protons in the ^{127}Pr nucleus. Standard values for the remaining CQPC model parameters (energy gap Δ, proton effective charge and effective g-factor) were used [5].

The results of our calculation for ^{127}Pr are presented in Fig. 4. Satisfactory agreement between theory and experiment was achieved. Root mean square deviations between the experimental and calculated excitation energies are ≈ 50 keV. It is worth emphasizing that our calculation was done with the standard set of CQPC model parameters and with core parameters based exclusively on the properties of ^{126}Ce. A somewhat better description of ^{127}Pr was obtained with a larger γ=21°, which is not consistent with the observed ^{126}Ce properties. This effect implies an influence of the odd proton on the core. The observed general agreement between experiment and theory supports the statement that the ^{127}Pr band is the negative parity decoupled band built on the $\pi h_{11/2}$ orbital.

These calculations predict the following properties for the ^{127}Pr nucleus, which represent future experimental

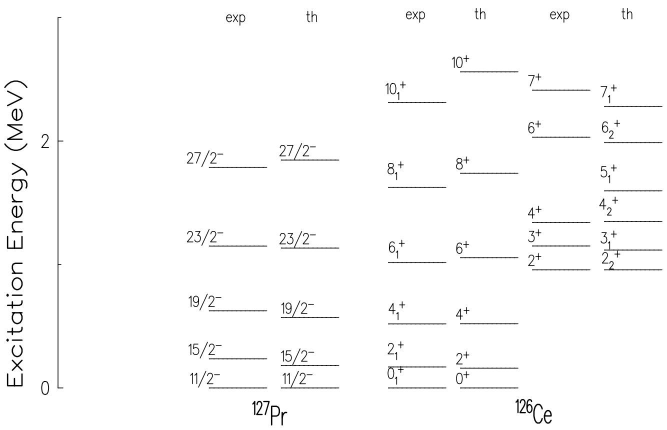

Fig. 4. $\pi h_{11/2}$ decoupled band in ^{127}Pr and positive parity states in ^{126}Ce. The experimental level schemes are compared with the theoretical calculations. The $6_2{}^+$ and $7_1{}^+$ levels from this study were not used in the fitting procedures. It follows from the calculation that these levels have their counterparts in the quasi γ band of the Davydov-Filippov model

tests:
$\mu(11/2_1{}^-)$=6.26μ_N;
B(E2;15/2$_1{}^-$→11/2$_1{}^-$)= 1.47B(E2;2$_1{}^+$→0$_1{}^+$)=0.68e^{2}b^2
using B(E2;2$_1{}^+$→0$_1{}^+$)=0.465(26)e^{2}b^2 from [2];
B(E2;19/2$_1{}^-$→15/2$_1{}^-$)= 1.08B(E2;15/2$_1{}^-$→11/2$_1{}^-$).

This work was supported in part by the U.S. National Science Foundation. We are grateful to the accelerator crew at the Stony Brook Nuclear Structure Laboratory for providing the beams and D.C.Radford for providing the RADWARE software package which was used in the data analyses.

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