PRAMANA — journal of physics

Vol. 57, No. 1
July 2001
pp. 171–174

Particle-rotor-model calculations in ^{125}I

HARIPRAKASH SHARMA[1*], B SETHI[1], P BANERJEE[1], RANJANA GOSWAMI[2], R K BHANDARI[2] and JAHAN SINGH[3]
[1]Saha Institute of Nuclear Physics, 1/AF Bidhan Nagar, Kolkata 700 064, India
[2]Variable Energy Cyclotron Centre, 1/AF Bidhan Nagar, Kolkata 700 064, India
[3]Maharshi Dayanand University, Rohtak 124 001, India
[*]Present Address: Department of Physics, Kalyani University, Kalyani 741 235, India

Abstract. Recent experimental data on ^{125}I has revealed several interesting structural features. These include the observation of a three quasiparticle band, prolate and oblate deformed bands, signature inversion in the yrast positive-parity band and identification of the unfavoured $\pi h_{11/2}$ band showing very large signature splitting. In the present work, particle-rotor-model calculations have been performed for the $\pi h_{11/2}$ band, using an axially symmetric deformed Nilsson potential. The calculations reproduce the experimental results well and predict a moderate prolate quadrupole deformation of about 0.2 for the band.

Keywords. Nuclear structure; particle-rotor-model calculations.

PACS Nos 27.60.+j; 21.10.Re; 21.60.Ev

1. Introduction

Detailed experimental studies have recently been carried out in ^{125}I by the present group [1,2]. These experiments have led to significant additions and alterations to the level scheme of ^{125}I reported earlier in the literature [3–5]. The level scheme based on the recent new data is given in ref. [2]. Important structural aspects inferred from these studies are: (i) the assignment of an oblate shape to the yrast positive-parity band and a prolate deformation for the $\pi g_{9/2}$ band, based on the sign of the multipole mixing ratios for the $\Delta I = 1$ in-band transitions; (ii) confirmation of a three quasiparticle configuration to an excited sequence of states depopulating by mixed M1/E2 transitions with a small but significant E2 transition rate of several single-particle units, indicating collectivity; (iii) identification of the weakly populated unfavoured signature partner of the prolate $\pi h_{11/2}$ band and the presence of very large signature splitting leading to an inversion in the level ordering, indicative of a rotation aligned nature. Besides, a signature inversion was observed in the positive-parity yrast band in ^{125}I as in all the lighter odd-A iodine isotopes at a spin of about 17/2. The above results permit a systematic study of all the odd-A iodine nuclei with $A =$ 119–125.

Motivated by the above experimental results, particle-rotor-model (PRM) calculations were performed in order to provide a better understanding of the structure of the $h_{11/2}$

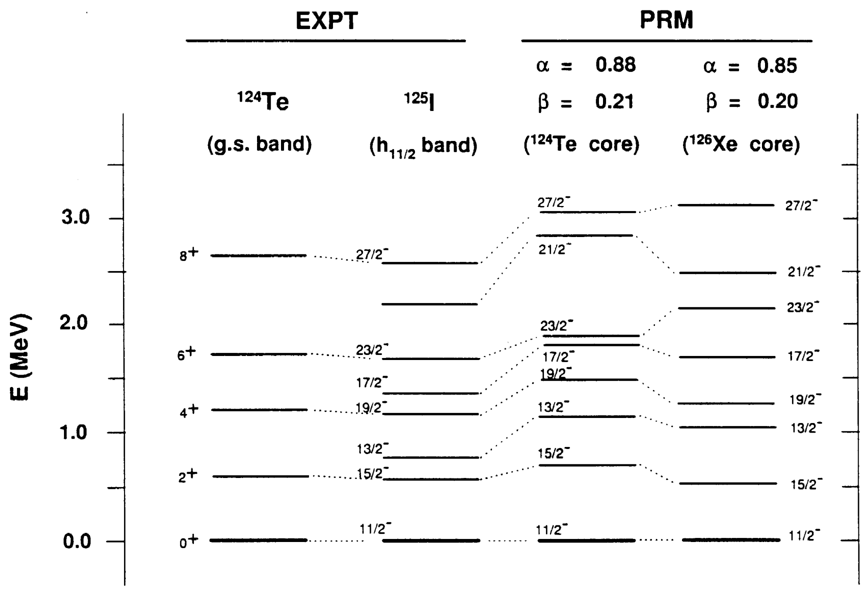

Figure 1. Comparison of the experimental energy levels of $h_{11/2}$ band in ^{125}I with the g.s. band of the ^{124}Te and PRM calculations with ^{124}Te and ^{126}Xe cores.

band in ^{125}I. This band has been tentatively interpreted in our eralier work [2] on the basis of the experimental data and the systematics of similar bands in the neighbouring odd-A iodine nuclei to have a rotaional character, as noted above. However, the level spacings of the band do not reflect the $I(I+1)$ pattern, characteristic of rotational sequences. The lack of lifetime information for the band members is a further hindrance in obtaining definite structural details.

2. Particle-rotor-model calculations

The level scheme of the $h_{11/2}$ band, shown in figure 1, closely resembles the ground state band of the neighbouring even–even ^{124}Te nucleus [6]. The interpretation of the latter band is not unambiguously reported in the literature although a recent work [6] indicates that an interacting boson model may explain the low energy states fairly well, favouring a vibrational nature. Considering the close resemblance between the $h_{11/2}$ band in ^{125}I and the yrast band in ^{124}Te, it may appear that the former band also has a vibrational character.

However, an earlier work by Lee *et al* [7] suggests a deformed shape for the ground state band in ^{124}Te, based on a dynamic deformation model [8] which shows a potential minimum at $\beta \sim 0.2$, independent of the non-axial deformation parameter γ.

A survey of the the $h_{11/2}$ band in the lighter odd-A $^{119-123}$I nuclei, studied up to high spins, show that the band has been interpreted to have a prolate deformation arising from the Nilsson configuration [550]1/2$^-$ [9–11]. This is consistent with the large signature splitting observed for the band in ^{119}I where the unfavoured signature band has been identified [9]. However, the weakly populated unfavoured band has not been observed in ^{121,123}I [10,11]. The identification of the 13/2$^-$ and 17/2$^-$ states in ^{125}I as members of the unfavoured sequence [2], based on their decay pattern, suggests that the $h_{11/2}$ band in ^{125}I may also have a structure similar to those in the lighter iodine nuclei, rather than a vibrational nature. Particle-rotor-model calculations have been previously used to understand the structure of the $h_{11/2}$ band in ^{121,123}I [12]. Accordingly, PRM calculations were performed for ^{125}I using both ^{124}Te and ^{126}Xe as the core. The ground state band in ^{126}Xe is reported to have a rotational collectivity [13,14].

The details of the PRM calculations are similar to those reported previously for ^{121,123}I [12]. The motion of the odd proton in deformed Nilsson orbit is coupled to the rotation of the core through the Coriolis interaction. The core has been assumed to be axially symmetric ($\gamma = 0°$). The experimental level energies of the ground state band in the core nucleus are provided for calculation of the moment of inertia. Nilsson parameters μ and κ were taken from ref. [15]. The deformation parameter β and the Coriolis attenuation factor α were used as the free parameters. Figure 1 shows the results of the calculations using ^{124}Te as the core for $\beta = 0.21$, $\gamma = 0°$ and $\alpha = 0.88$. They appear to reproduce the experimental spectrum fairly well. Although the predicted energies are higher for all the states, the large signature splitting leading to an inversion of the level ordering is well predicted. This lends support to the interpretation of the $h_{11/2}$ band in ^{125}I as a decoupled band with a prolate deformation. The band is expected to be moderately deformed with $\beta \sim 0.2$. Although an axial symmetric core seems to predict the observed spectrum reasonably well, it is possible that a triaxial-core (non-zero γ) may lead to even better agreement.

Similar calculations were performed with a ^{126}Xe core where the experimental energies of the ground state band in ^{126}Xe [14] were used. The results, shown in figure 1, indicate that the low energy states with spins up to 21/2$^-$ are somewhat better predicted compared with the calculations using ^{124}Te core. This lends further support to the interpretation that the $h_{11/2}$ band in ^{125}I is prolate deformed with a quadrupole deformation of about 0.2. It is therefore reasonable to infer that the band in ^{125}I has a structure which is similar to the $h_{11/2}$ bands in ^{119,121,123}I [9–11]. More definite conclusions regarding the structure of the band can be inferred only if lifetime information are available for the states in ^{125}I.

Acknowledgement

One of the authors (HS) is grateful to Prof Bikash Sinha, Director, SINP, for providing the facilities to carry out this work.

References

[1] Hariprakash Sharma, B Sethi, Ranjana Goswami, P Banerjee, R K Bhandari and Jahan Singh, *Phys. Rev.* **C59**, 2446 (1999)
[2] Hariprakash Sharma, B Sethi, P Banerjee, Ranjana Goswami, R K Bhandari and Jahan Singh, *Phys. Rev.* **C63**, 014313-1 (2001)
[3] U Hagemann, H J Keller and H F Brinckmann, *Nucl. Phys.* **A289**, 292 (1977)
[4] R E Shroy, D M Gordon, M Gai, D B Fossan and A K Gaigalas, *Phys. Rev.* **C26**, 1089 (1982)

[5] J Katakura, M Oshima, K Kitao and H Iimura, *Nuclear Data Sheets* **70**, 217 (1993)
[6] N Warr, S Drissi, P E Garrett, J Jolie, J Kern, H Lehmann, S J Mannanal and J-P Vorlet, *Nucl. Phys.* **A636**, 379 (1998)
[7] C S Lee, J A Cizewski, D Barker, G Kumbartzki, R Tanczyn, R G Henry and L P Farris, *Nucl. Phys.* **A530**, 58 (1991)
[8] A Subber, W D Hamilton, P Park and K Kumar, *J. Phys.* **G13**, 161 (1987)
[9] S Tormanen, S Juutinen, R Julin, A Lampinen, E Makela, M Piiparinen, A Savelius, A Virtanen, G B Hagemann, Ch Droste, W Karczmarczyk, T Morek, J Srebrny and K Starosta, *Nucl. Phys.* **A613**, 282 (1997)
[10] Y Liang, D B Fossan, J R Hughes, D R LaFosse, T Lauritsen, R Ma, E S Paul, P Vaska, M P Waring, N Xu and R A *Wyss, Phys. Rev.* **C44**, R578 (1991)
[11] D L Balabanski, G Rainovski, N Blasi, G Falconi, G Lo Bianco, S Signorelli, D Bazzacco, G de Angelis, D R Napoli, M A Cardona, A J Kreiner and H Somacal, *Phys. Rev.* **C56**, 1629 (1997)
[12] R Goswami, B Sethi, M S Sarkar and S Sen, *Z. Phys.* **A352**, 391 (1995)
[13] R Wyss, A Granderath, R Bengtsson, P Von Brentano, A Dewald, A Gelberg, A Gizon, J Gizon, S Harissopulos, A Johnson, W Lieberz, W Nazarewicz, J Nyberg and K Schiffer, *Nucl. Phys.* **A505**, 337 (1989)
[14] F Seifferta, W Lieberza, A Dewalda, S Freunda, A Gelberga, A Granderatha, D Lieberza, R Wirowskia and P von Brentanoa, *Nucl. Phys.* **A554**, 287 (1993)
[15] Jing-ye Zhang, N Xu, D B Fossan, Y Liang, R Ma and E S Paul, *Phys. Rev.* **C39**, 714 (1989)