Spin assignments of yrast bands in odd-odd isotopes $^{118-132}$Cs

Yunzuo Liu, Jingbin Lu, Yingjun Ma, Guangyi Zhao, and Hua Zheng
Department of Physics, Jilin University, Changchun 130023, People's Republic of China
and Institute of Modern Physics, Academic Sinica, Lanzhou 730000, People's Republic of China

Shangui Zhou
Department of Technical Physics, Peking University, Beijing 100871, People's Republic of China

(Received 21 January 1998)

The excitation energy systematics of $\pi h_{11/2} \otimes \nu h_{11/2}$ yrast bands of odd-odd isotopes $^{118-132}$Cs are studied, and as a result of this study we suggest that the spin values of lowest observed states of yrast bands of ^{118,122,124,126,128}Cs be reassigned as 8, 9, 9, 9, and 10, respectively. These new spin assignments are also supported by the argument of alignment additivity. [S0556-2813(98)02309-7]

PACS number(s): 21.10.Hw, 27.60.+j

Among the eight odd-odd isotopes $^{118-132}$Cs [1–8], ^{130}Cs is the only case where the spin of the lowest observed state of the $\pi h_{11/2} \otimes \nu h_{11/2}$ yrast band was definitely assigned through experiments with sufficient spectroscopic information. In all other cases, the spins of their yrast bands were assigned tentatively by the respective original authors. The reliability of some of the tentatively assigned spins has been questioned by systematics study [5] and theoretical study [9] of systematic features of the low-spin signature inversion. In the present work we try to reevaluate these tentatively assigned spin values by studying the excitation energy systematics of the $\pi h_{11/2} \otimes \nu h_{11/2}$ bands of odd-odd isotopes $^{118-132}$Cs under the assumptions that (1) the spin assignment of the lowest observed state of the $\pi h_{11/2} \otimes \nu h_{11/2}$ bands in ^{130}Cs is reliable and (2) with increasing neutron number, the corresponding level spacings of $\pi h_{11/2} \otimes \nu h_{11/2}$ bands of $^{118-132}$Cs vary smoothly with the variation trend similar to that of $\pi h_{11/2}$ yrast bands of neighboring odd-*A* isotopes $^{117-133}$Cs and that of ground state bands of neighboring even-even isotopes $^{116-130}$Xe.

In Fig. 1, triangles and circles indicate the level positions of the $\pi h_{11/2} \otimes \nu h_{11/2}$ bands of $^{118-132}$Cs based on the previous spin assignments [1–8] and spin assignments suggested by the present study, respectively. Smooth curves connecting circles pass through the level positions of ^{130}Cs as required by the first assumption and they have the varia-

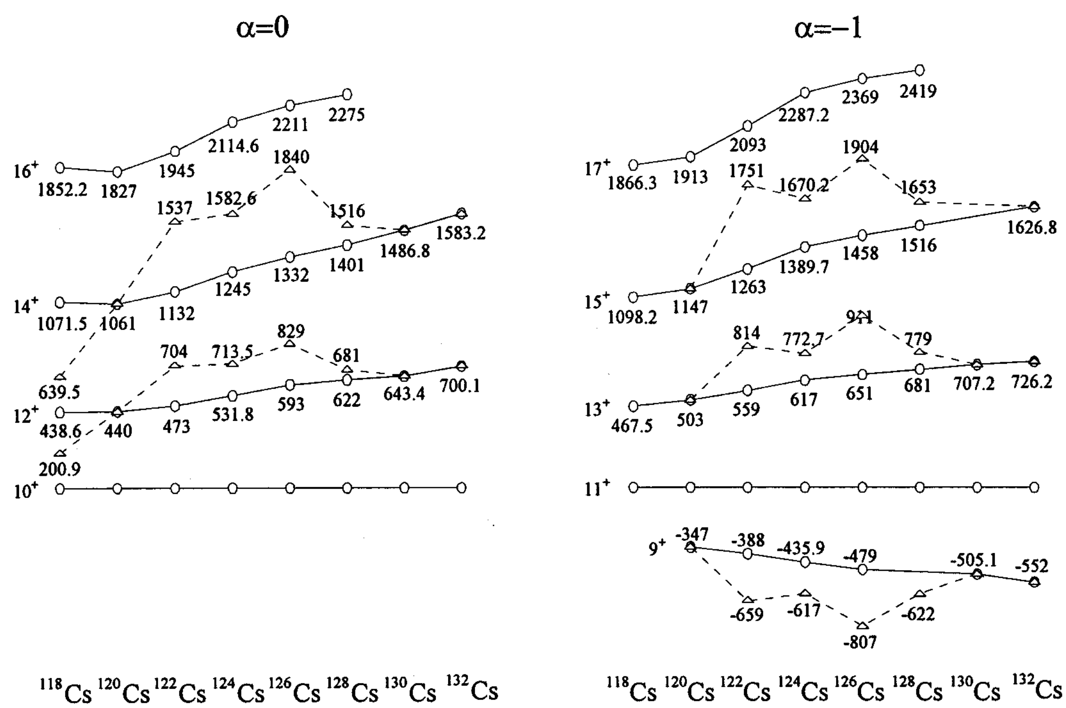

FIG. 1. Excitation energy systematics of $\pi h_{11/2} \otimes \nu h_{11/2}$ bands in doubly odd isotopes $^{118-132}$Cs. Triangles and circles indicate the level positions based on previous and present spin assignments, respectively. Curves connecting circles were required to pass through the level positions of ^{130}Cs($I_0=9$) whose spin is considered to be firmly assigned. Energies are given in keV.

tion trend as required by the second assumption. In order to shift the level positions from triangles to circles the previous spin values 10, 6, 7, 5, and 9 of the lowest observed states of yrast bands of ^{118,122,124,126,128}Cs have to be replaced by new values 8, 9, 9, 9, and 10, respectively, while the previous spin values of ^{120}Cs [2] and ^{132}Cs [8] remain unchanged. Practically, no matter how the spin values of these isotopes are adjusted one is not able to obtain other smooth curves which pass through the level positions of ^{130}Cs and, at the same time, have a more reasonable variation trend than that of the smooth curves of Fig. 1.

These new spin assignments are also supported by the argument of alignment additivity. Figure 2(a) shows that the alignments $i_{np}(I_0=9)$ of ^{124}Cs deduced by using the new spin value $I_0=9$ are much closer to the sum of proton alignments i_p of ^{123}Cs [10] and neutron alignments i_n of ^{123}Xe [11] than $i_{np}(I_0=7)$ based on previous spin value $I_0=7$. A similar situation occurs in ^{126}Cs as shown in Fig. 2(b) where the alignments $i_{np}(I_0=5)$ based on previous spin assignment of $I_0=5$ are even far away from the sum i_p+i_n of neighboring odd-A isotopes ^{125}Cs [12] and ^{125}Xe [13], while the $i_{np}(I_0=9)$ based on the present spin assignment are very close to the sum i_p+i_n.

In our previous study on spin assignments of yrast bands of odd-odd nuclei in the mass region of $A\sim130$ [14], three possible choices were suggested for the spin assignments of odd-odd Cs isotopes on the basis of excitation energy systematics, where the argument of alignment additivity was not studied. The spin values 8, 8, 9, 9, 9, 10, 9, and 9 for $^{118-132}$Cs, respectively, adopted in the present work correspond to the second choice of Ref. [14]. Level schemes of $^{118-132}$Cs based on spin values suggested in the present work are shown in Fig. 3 where the level with $I=12$ is taken as reference for comparison. The expected similarity of level schemes of different isotopes and the gradual variation trend of level structure with increasing neutron number are revealed in Fig. 3 while these systematic features would not be seen in the level schemes based on the previous spin assignments.

The phenomenon of low-spin signature inversion in odd-odd Cs isotopes had been studied by Tajima [9] in the framework of the particle-triaxial-rotor model with the inclusion of the p-n residual interaction. The predictions of Ref. [9] are compared with the experimental results based on the previous and present spin assignments in Table I. The theory [9] predicted that the low-spin signatures are inverted for all odd-odd Cs isotopes studied and inversion spin (I_{inv}), at which the signature splitting changes the sign, increases with increasing neutron number. These two predictions are in good agreement with experimental results based on the spin assignments suggested in the present work except that the predicted inversion spins are approximately $2\hbar$ lower than the experimental values. The latter differences of $\sim2\hbar$ can probably be explained by noting the fact that in Tajima's calculation [9], where both the p-n residual interaction and γ deformation were taken into account, the author first performed an extensive study to see what kind of combination of γ deformation and p-n interactions is most suitable to reproduce the experimental data of ^{124}Cs and, then, calculated the signature splittings of other Cs isotopes. The point is that in Tajima's calculation, the experimental data of ^{124}Cs were taken as reference and the previous spin $I_0=7$ for ^{124}Cs was adopted in that calculation. If, in Tajima's calculation, the previous spin value $I_0=7$ was replaced by the present value $I_0=9$, the agreement between experiment and theory would probably be improved.

In summary, the excitation energy systematics of $\pi h_{11/2}\otimes\nu h_{11/2}$ yrast bands of odd-odd isotopes $^{118-132}$Cs were studied, and as a result we suggested that the spin values of the lowest observed states of $\pi h_{11/2}\otimes\nu h_{11/2}$ yrast bands of ^{118,122,124,126,128}Cs be reassigned as 8, 9, 9, 9, and 10 to replace the previous values 10, 6, 7, 5, and 9, respectively.

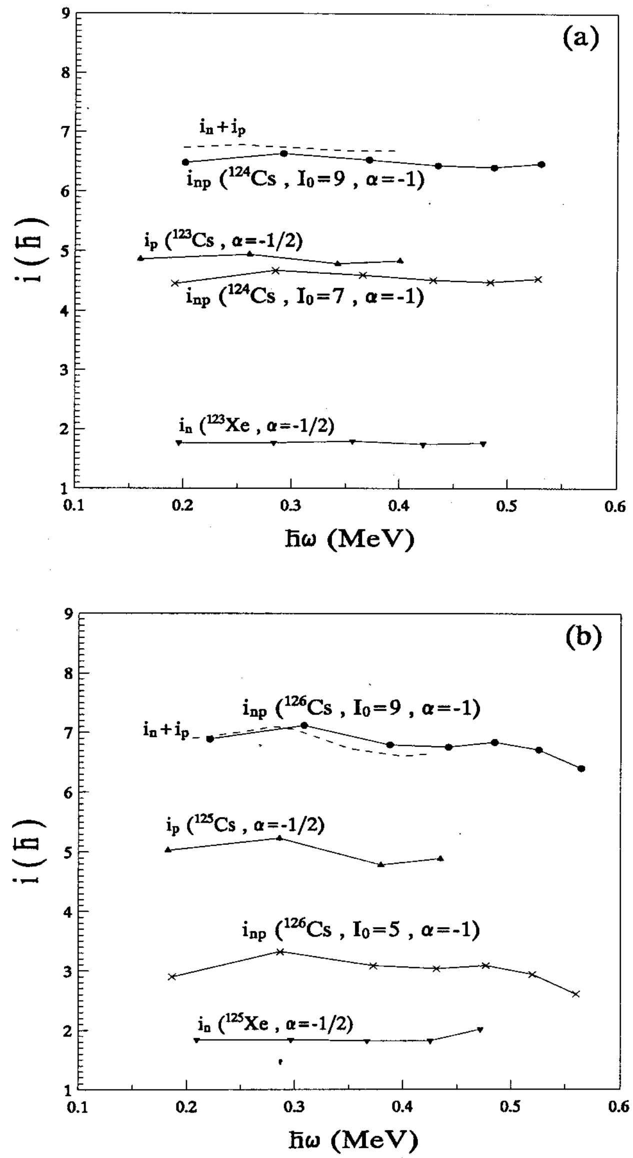

FIG. 2. (a) Alignment i_{np}, i_p, and i_n of $\pi h_{11/2}\otimes\nu h_{11/2}$, $\pi h_{11/2}$, and $\nu h_{11/2}$ bands in ^{124}Cs [4], ^{123}Cs [10], and ^{123}Xe [11], respectively. The reference core parameters (J_0,J_1) used are (14,40), (12, 53), and (21,26) for ^{124}Cs, ^{123}Cs, and ^{123}Xe, respectively. J_0 and J_1 are in units of MeV^{-1} $\hbar^2$ and MeV^{-3} $\hbar^4$, respectively. Only the favored signature is presented. (b) Same as (a) but for ^{126}Cs [5], ^{125}Cs [12], and ^{125}Xe [13]. The reference core parameters (J_0,J_1) used for ^{126}Cs, ^{125}Cs, and ^{125}Xe are (10,56), (9.0,51), and (19,36), respectively.

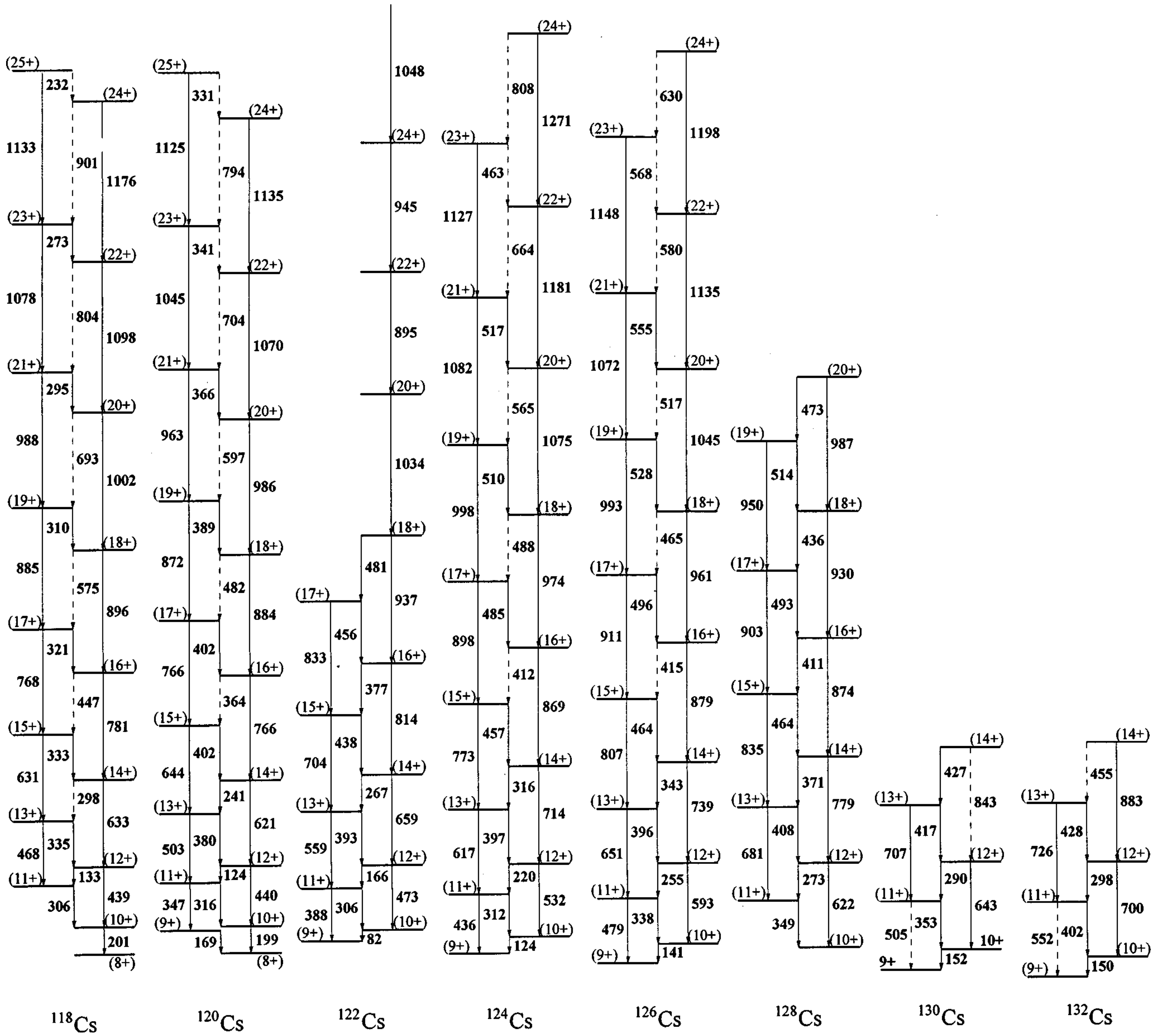

FIG. 3. Level schemes of $\pi h_{11/2} \otimes \nu h_{11/2}$ bands in $^{118-132}$Cs based on the present spin assignments. The states with $I=12$ are taken as reference for comparison. Energies are given in keV.

TABLE I. Summary of previous and present I_0's and comparisons of the systematic features of signature inversion based on previous and present spin assignments and those calculated by Tajima [9].

	$I_0(\hbar)$		$I_{inv}(\hbar)$			Low spin signature inverted		
Isotopes	Previous	Present	Previous	Present	Tajima[a] [9]	Previous	Present	Tajima[b] [9]
^{118}Cs	10 [1]	8	16.5	14.5		Yes	Yes	
^{120}Cs	8 [2]	8	16.5	16.5	14.5	Yes	Yes	Yes
^{122}Cs	6 [3]	9	14.5	17.5		No	Yes	
^{124}Cs	7 [4]	9	16.5	18.5	16.0	Yes	Yes	Yes
^{126}Cs	5 [5]	9	17.5	21.5	19.0	Yes	Yes	Yes
^{128}Cs	9 [6]	10			20.5	No	Yes	Yes
^{130}Cs	9 [7]	9				No	Yes	
^{132}Cs	9 [8]	9				Yes	Yes	

[a]Estimated from Fig. 9 of Ref. [9] with uncertainties $\pm 0.5\hbar$.
[b]Seen from Fig. 9 of Ref. [9].

These new spin assignments are also supported by the argument of alignment additivity. Systematic features of low-spin signature inversion of odd-odd Cs isotopes predicted by Tajima's systematic calculations in the framework of the particle-triaxail-rotor model with the inclusion of the *p*-*n* interaction are in good agreement with the experimental results based on the present spin assignments. However, the spin assignments suggested in the present work need to be confirmed by future experimental studies.

The authors are grateful to Professor C.-X. Yang of CIAE in Beijing for his interest and helpful discussions. This work was supported by the National Natural Science Foundation of China.

[1] J. F. Smith, *et al.*, Phys. Lett. B **406**, 7 (1997).
[2] B. Cederwall *et al.*, Nucl. Phys. **A542**, 454 (1992).
[3] N, Xu, Y. Liang, R. Ma, E. S. Paul, D. B. Fossan, and H. M. Latvakoski, Phys. Rev. C **41**, 2681 (1990).
[4] T. Komatsubara *et al.*, Z. Phys. A **335**, 113 (1990).
[5] T. Komatsubara *et al.*, Nucl. Phys. **A557**, 419c (1993).
[6] E. S. Paul, D. B. Fossan, Y. Liang, and N. Xu, Phys. Rev. C **40**, 619 (1989).
[7] P. R. Sala, N. Blasi, G. L. Bianco, A. Mazzoleni, R. Reinhardt, K. Schiffer, K. P. Schmittgen, G. Siems, and P. V. Brentano, Nucl. Phys. **A531**, 383 (1991).
[8] T. Hayakawa *et al.*, Z. Phys. A **357**, 349 (1997).
[9] N. Tajima, Nucl. Phys. **A572**, 365 (1994).
[10] J. R. Hughes, D. B. Fossan, D. R. LaFosse, Y. Liang, P. Vska, M. P. Waring, and J.-Y. Zhang, Phys. Rev. C **45**, 2177 (1992).
[11] W.-D. Zeitz, D. Alber, H. Grawe, H. Haas, R. Keitel, H.-E. Mahnke, W. Semmler, and R. Sielemann, Z. Phys. A **308**, 227 (1982).
[12] J. R. Hughes, D. B. Fossan, D. R. LaFosse, Y. Liang, P. Vaska, and M. P. Waring, Phys. Rev. C **44**, 2390 (1991).
[13] A. Granderath, D. Lieberz, A. Gelberg, S. Freund, W. Lieberz, R. Wiroski, P. Von Brentano, and R. Wyss, Nucl. Phys. **A524**, 153 (1991).
[14] Yunzuo Liu, Jingbin Lu, Yingjun Ma, Shangui Zhou, and Hua Zheng, Phys. Rev. C **54**, 719 (1996).