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$g_{9/2}$ AND $h_{11/2}$ BANDS IN ^{121,123,125}Cs

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Résumé. — Des cascades de transitions E2 pures dans ^{121,123,125}Cs forment les bandes découplées résultant de l'existence d'un proton dans la plus basse orbitale de la couche $h_{11/2}$. La séquence de niveaux $\Delta I = 1$ a ses origines dans un trou de proton dans la couche $g_{9/2}$. Ces résultats impliquent une forme prolate pour ces noyaux de césium.

Abstract. — Cascades of stretched E2 transitions in ^{121,123,125}Cs constitute the decoupled bands generated from a proton in the lowest orbital of the $h_{11/2}$ shell. A $\Delta I = 1$ sequence originates from a hole in the $g_{9/2}$ proton shell. The results for both the $h_{11/2}$ and the $g_{9/2}$ bands imply a prolate shape of these nuclei.

Since the discovery of the band structure built on a unique-parity state in odd-A La isotopes [1], many bands based on $11/2^-$ states have been established in the same nuclear region ($50 \leqslant Z, N \leqslant 82$). They show *strong-coupled* structure generated from a neutron-hole state in Ba, Ce, Nd nuclei [2] and *decoupled* one based on a proton particle state in I isotopes [3] (for example). The rotation-aligned model [4] has been successful in explaining such features. Further studies extended to other nuclei are interesting in order to ascertain the evolution of these properties of such transitional nuclei as a function of their neutron and proton numbers.

Results are reported here for odd-A Cs isotopes which were produced by (^{12}C, p2n) reactions. Preliminary data [5] were published simultaneously with those [6] of the Stony Brook group who used other reactions to investigate neutron-deficient Cs nuclei.

The experiments were carried out with the external beam of ^{12}C ions from the Grenoble variable energy cyclotron, at various energies between 55 and 63 MeV. Leadbacked targets of about 2 mg/cm^2 were made with metallic tin enriched to 79.6 %, 66.5 % and 84.4 % in ^{112}Sn, ^{114}Sn and ^{116}Sn, respectively. The ^{112}Sn target was obtained from the oxide after reduction with hydrogen.

Excitation functions, in-beam and out-of-beam single spectra and the angular distribution of γ-rays (6 angles including 0° to the beam) were measured. The γ-γ-t coincidence experiments were performed with two coaxial Ge(Li) detectors. Due to the fact that the (^{12}C, 3n), (^{12}C, p2n) and (^{12}C, αxn) reactions were competing, the lines in the Cs isotopes were identified by seeking coincidences between the γ-lines and the evaporated particles. The protons and α particles were detected with a silicon detector placed near the target and covered with a 400 μg/cm^2 aluminium absorber.

Energies, intensities and A_2 values of the transitions placed in the partial level schemes of ^{121,123,125}Cs (Figs. 1 and 2) are listed in table I.

From γ-p and γ-γ coincidence spectra, two types of cascades have been identified. The first one consists of stretched E2 transitions with energies similar to those of the level spacings in the even-even Xe cores as indicated in figure 1. This is a characteristic property of decoupled bands based on an $11/2^-$ state generated from the $h_{11/2}$ proton shell. As in the odd-A lanthanum cases [1], the Fermi surface is located on the lowest orbital of the $h_{11/2}$ shell and the coupling of a prolate core with the odd quasi-proton gives rise to a $\Delta I = 2$ sequence [7]. The $11/2^-$, $15/2^-$, $19/2^-$... levels are strongly populated in the de-excitation of the compound nucleus produced with ^{12}C ions; the unfavored states ($I = j + 1$, $j + 3$, $j + 5, \ldots$), on the contrary, are difficult to identify. Despite this difficulty, the assignments of the $21/2^-$ levels in ^{121,123}Cs and of the $17/2^-$ in ^{125}Cs could be made. They are supported by the strongly negative A_2

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TABLE I

Transitions placed in the partial level schemes of $^{121,123,125}Cs$

^{121}Cs

E_γ (keV)	Transition	I_γ ([a])	A_2^{exp}/A_0
—	—	—	—
244.7	$11/2^+ \to 9/2^+$	47	0.03(1)
276.1	$13/2^+ \to 11/2^+$	31	0.12(2)
286.0	$15/2^- \to 11/2^-$	100	0.33(3)
303.3	$15/2^+ \to 13/2^+$	27	0.09(2)
327.6	$17/2^+ \to 15/2^+$	19	0.02(5)
347.1	$19/2^+ \to 17/2^+$	10	− 0.02(4)
360.4	$21/2^+ \to 19/2^+$	7	0.00(6)
366.0	$25/2^+ \to 23/2^+$	6	0.11(2)
367.8	$23/2^+ \to 21/2^+$	8	0.09(2)
472.2	$19/2^- \to 15/2^-$	82 ([b])	0.34(2)
521 ([c])	$13/2^+ \to 9/2^+$	8	0.17(4)
579.8	$15/2^+ \to 11/2^+$	9	0.30(2)
615.0 ([c])	$23/2^- \to 19/2^-$	< 58	0.32(2)
631.5	$17/2^+ \to 13/2^+$	13	0.29(3)
675 ([c])	$19/2^+ \to 15/2^+$	10	0.30(2)
708 ([c])	$21/2^+ \to 17/2^+$	18	0.27(7)
726.1	$27/2^- \to 23/2^-$	39	0.30(2)
728 ([c])	$23/2^+ \to 19/2^+$	9	0.30(3)
734 ([c])	$25/2^+ \to 21/2^+$	7	0.34(2)
816.0	$31/2^- \to 27/2^-$	20	0.16(2)
843.6	$21/2^- \to 19/2^-$	7	− 0.48(5)
894.0	$35/2^- \to 31/2^-$	8	0.19(4)

^{123}Cs

E_γ (keV)	Transition	I_γ ([a])	A_2^{exp}/A_0
—	—	—	—
269.1	$11/2^+ \to 9/2^+$	16	0.19(7)
303.7	$13/2^+ \to 11/2^+$	9	0.12(6)
320.6	$15/2^- \to 11/2^-$	100	0.32(4)
337.0	$15/2^+ \to 13/2^+$	7	0.15(7)
366.3	$17/2^+ \to 15/2^+$	5	0.08(5)
388.8	$19/2^+ \to 17/2^+$	3	0.04(3)
522.4	$19/2^- \to 15/2^-$	71	0.36(4)
572.7	$13/2^+ \to 9/2^+$	9	0.30(3)
640 ([b])	$15/2^+ \to 11/2^+$	8 ([b])	
685.5	$23/2^- \to 19/2^-$	36	0.31(1)
703 ([b])	$17/2^+ \to 13/2^+$	8 ([b])	
730.7	$(21/2^-) \to 19/2^-$	14	− 0.51(3)
755 ([b])	$19/2^+ \to 15/2^+$	9 ([b])	
800.7	$27/2^- \to 23/2^-$	20	0.13(20)
870	$31/2^- \to 27/2^-$	7 ([b])	0.37(18)

^{125}Cs

E_γ (keV)	Transition	I_γ ([a])	A_2^{exp}/A_0
366.1	$15/2^- \to 11/2^-$	100	0.25(3)
572.8	$19/2^- \to 15/2^-$	52	0.27(2)
648.3	$(17/2^-) \to 15/2^-$	18	− 1.05(18)
760.5	$23/2^- \to 19/2^-$	21	0.18(10)
870.9	$27/2^- \to 23/2^-$	17	0.18(7)

([a]) Relative intensities normalized to the $15/2^- \to 11/2^-$ transitions.
([b]) Value deduced from the γ-γ coincidence spectra.
([c]) Unresolved line in the singles γ-ray spectrum. The energy is obtained from γ-γ spectra.

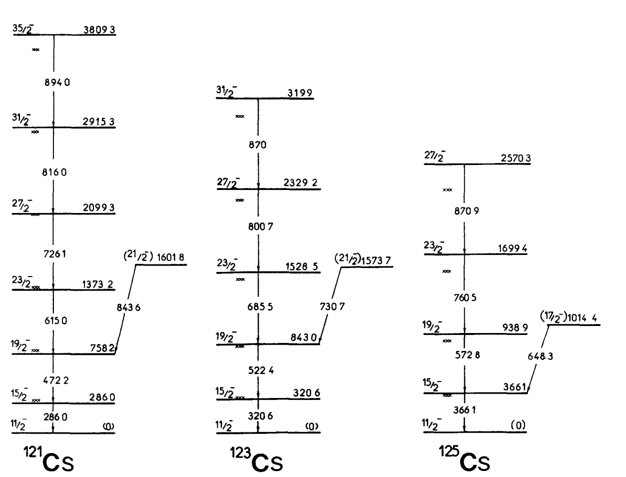

FIG. 1. — Decoupled bands in odd-*A* Cs isotopes. The crosses indicate the levels in the ground bands of the even-even Xe neighbouring nuclei.

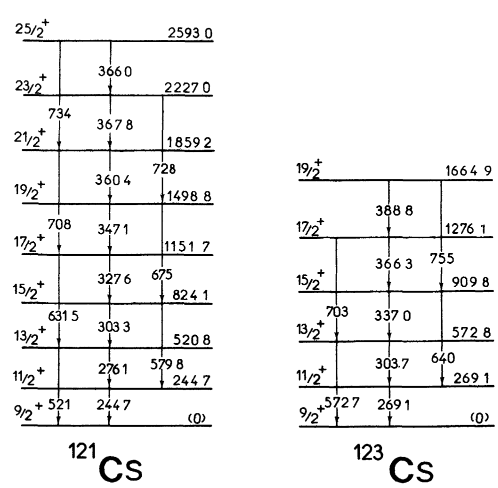

FIG. 2. — The $g_{9/2}$ bands in $^{121,123}Cs$.

coefficients of the M1 + E2 transitions which de-excite them.

The second kind of band found has a $\Delta I = 1$ rotational-like character. The assignment is based on three main arguments : i) Positive A_2 coefficients correspond to positive δ (E2/M1) mixing ratios for $I + 1 \to I$, M1 + E2 transitions in bands generated from proton-hole configurations. ii) For $Z = 55$ and for a positive β deformation in the range $0.1 \leqslant \beta \leqslant 0.3$, the only possible hole in the highest

Nilsson orbital of a shell is a $g_{9/2}$ one. iii) Ekström *et al.* [8] have observed a 9/2 isomer in ^{121}Cs which is very likely the basic state of the $\Delta I = 1$ bands shown in figure 2. This band, based on a $1g_{9/2}$ hole-state was already known in odd-*A* Sb [9] and I [4] nuclei and observed in ^{121}Cs [10].

The whole set of data relative to both $h_{11/2}$ and $g_{9/2}$ collective excitations is compatible with the triaxial-rotor-plus-particle model [8]. Indeed a prolate-type triaxial core coupled to a rotation-aligned $h_{11/2}$ proton and to a $g_{9/2}$ proton-hole reproduces the main features such as level energies, mixing ratios and branching ratios. The experimental evidence for triaxial shapes has been shown [11] in the similar case of light La nuclei.

Information on the behaviour of these Cs nuclei at high angular momentum can be extracted by considering the moment of inertia and the rotational frequency. A comparison of backbending plots for nuclei in the Cs region is shown in figure 3. It is seen that the even-even neighbouring nuclei do backbend between the 10^+ and 12^+ levels. In spite of the small number of experimental points, it seems that the $g_{9/2}$ positive-parity band in ^{121}Cs behaves like the yrast band in ^{122}Ba at almost the same rotational frequency. On the other hand, the $h_{11/2}$ decoupled band in ^{121,123}Cs does not backbend. These facts are in agreement with deductions made from La data [12] which, in the rotation-aligned model, suggest that the backbending is mainly caused by two $h_{11/2}$ protons.

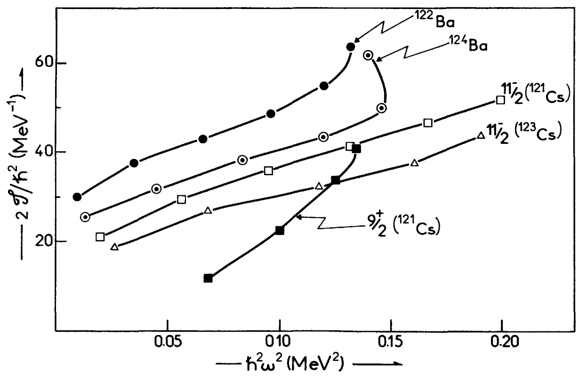

FIG. 3. — Backbending plots for nuclei in the Cs region.

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