NEW ISOMER AND LOW-ENERGY INTRINSIC STATES IN ^{127}Ba

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Abstract

A new isomer ($T_{1/2}$ = 1.9 ± 0.2 seconds) has been identified in ^{127}Ba. A $7/2^-$ spin and parity assignment has been deduced. The ground state of ^{127}Ba is established as a $1/2^+$ state. New positive parity band structures have been observed.

1. Introduction

From in-beam experiments performed with the ^{118}Sn(^{12}C, 3n) reaction, collective band structures have been easily identified in ^{127}Ba [1]. An odd-parity rotational-like band developed on a $9/2^-$ base state has been explained in terms of an $h_{11/2}$ neutron-hole coupled to a triaxial core. An even-parity band based upon a $7/2^+$ state has also been associated with the coupling of a $g_{7/2}$ neutron-hole to the core with the Fermi energy located in the highest orbital of the shell. More generally, the experimental collective level patterns excited by heavy ion reactions in the odd-A neutron-deficient bariums (N=67 to N=77) have established prolate-type nuclear shapes for these nuclei by a treatment in the framework of the triaxial rotor-plus-particle model [2]. Nevertheless, the experimental systematics on high spin states excited via heavy ions reactions give only a partial knowledge of these isotopes. Indeed, transitional nuclei of this region are known to be rather soft and both prolate and oblate nuclear shapes have been theoretically predicted [3].

In the special case of ^{127}Ba, the information about low-spin, low-energy states is very poor. In previous experiments the half-life was not well determined. Two different values were proposed by d'Auria et al [4], one associated with a high spin state, $T_{1/2}$ = 10 minutes and another one corresponding to a low-spin state, $T_{1/2}$ = 18 minutes. In a more recent measurement, only one half-life has been reported ($T_{1/2}$ = 13.0 ± 0.5 minutes) by Pathak and Preiss [5] from the decay of ^{127}La to ^{127}Ba. The spin and parity of the ground state of ^{127}Ba have not been determined from these previous measurements.

From the in-beam experiment performed at Grenoble with the ^{118}Sn(^{12}C, 3n) reaction on lead-backed targets, the lowest state observed was a $9/2^-$, identified by systematics with the heavier odd-A isotopes. In this work, it was impossible to decide if this $9/2^-$ state is an isomeric level or eventually the ground state of the ^{127}Ba nucleus.

Such a complicated situation has suggested to include the study of the ^{127}Ba isotope in the syste-

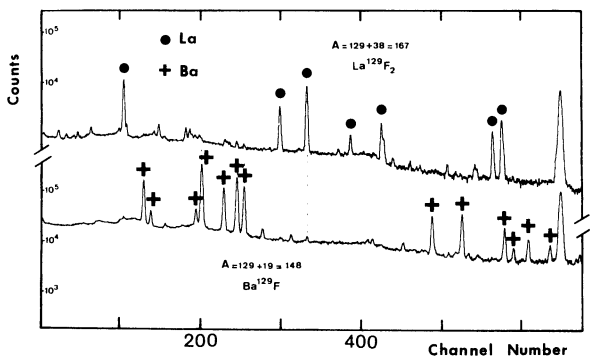

Fig. 1 : Comparison between gamma singles spectra for samples collected at A = 129 + 19 (BaF^+ ions) and at A = 129 + 38 (LaF_2^+ ions)

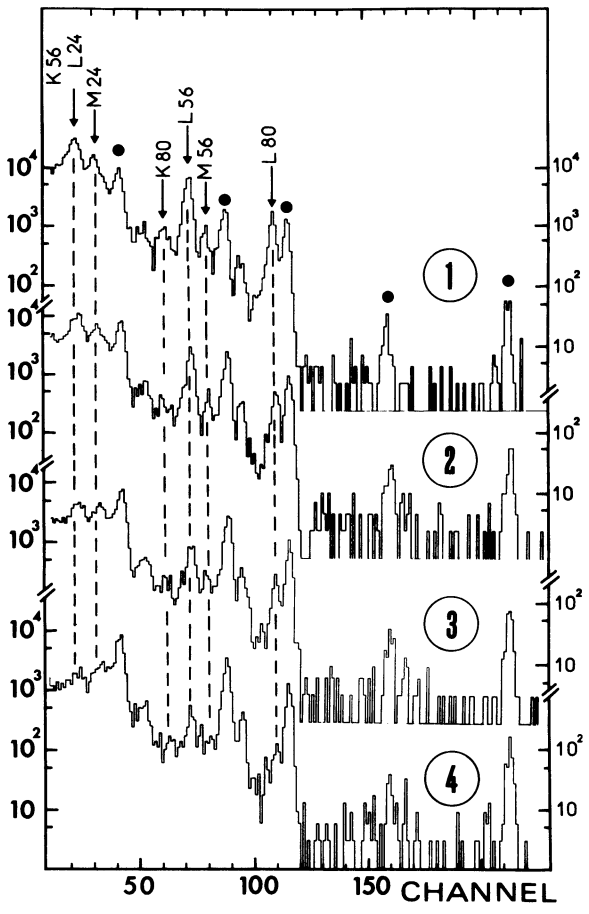

Fig. 2 : Part of a multispectrum analysis on the conversion electrons of ^{127m}Ba. The collection time was 5 seconds. Each spectrum was recorded during 1 second. The spectra shown have a time separation of 2 seconds. Lines labelled with a point belong to ^{127}Ba ($T_{1/2}$ = 13 minutes).

matic search on low-energy isomeric states undertaken at Isocèle II, using the new extraction possibilities of barium and lanthanum nuclei.

2. Experimental techniques

The isotopes studied in the present paper have been produced by bombardment of molten cerium metallic targets with a 280 MeV ^{3}He beam or a 200 MeV proton beam. The barium and lanthanum isotopes have been extracted at Isocele II, using the new fluoruration technique based on the volatility differences of the fluorides [6]. The efficiency of the method is demonstrated in figure 1.

The mass separated samples were collected on a tape driver and transported in front of the detectors. The identification of the nuclei was mainly based upon singles measurements carried out with high resolution Ge(Li), X-ray intrinsic Ge and Si(Li) detectors. Conversion electron spectra have been recorded with a magnetic selector [7]. The multispectrum analysis was performed on the γ-ray singles and the conversion electron spectra (8 time groups per spectrum).

3. Experimental results

In γ-ray singles spectra recorded with Ge(Li) detectors on $^{127}BaF^{+}$ samples collected at a mass A = 146, one new line at 56.2 keV and Ba X-rays have been identified with a new half-life of 1.9 ± 0.2 seconds. From a multispectrum analysis (8 groups of 1 second) of conversion electron spectra on samples collected during 5 seconds (figure 2), the same half-life has been observed for the strongly converted transitions at 24.2, 56.2 and 80.2keV (figure 3). The multipolarities of these low-energy transitions have been determined. From γ-X and γ-e^{-} coincidences the (80.2 ± 0.2) keV (E3) transition appears as the cross-over of the two (24.2±0.1) keV, (M2) and (56.2±0.1) keV, (M1,E2) transitions.

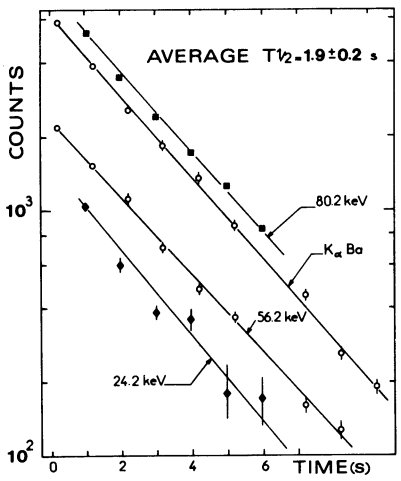

Fig. 3 : Decay curves of low energy transitions observed in ^{127m}Ba. The open circles show measurements taken with a Ge(Li) detector while the diamonds show the Si(Li) measurements and the squares the measurements with the electron selector.

With the ^{127}La F_2^{+} samples collected at a mass A = 165, the γ-ray singles spectra show a lot of new transitions. Indeed, as the ground state of ^{127}La has spin and parity $11/2^{-}$ [8], its decay feeds levels at relatively high spins in ^{127}Ba. The partial level scheme established mainly from γ-γ coincidences is reproduced in figure 4. Several points have to be mentioned to show the complement between the decay and in-beam measurements. The negative parity band already observed in the $^{118}Sn(^{12}C,3n)$ reaction [1] is fed up to the $15/2^{-}$ level at 777 keV. In addition to the previously identified states $9/2^{-}$, $11/2^{-}$, $13/2^{-}$, $15/2^{-}$, a lower energy level is established at 79.4 keV below the $9/2^{-}$ state mainly by prompt γ-γ coincidences (figure 5). This level can be identified as a $7/2^{-}$, by analogy with the $h_{11/2}$ negative parity structures detected in lighter odd-A barium isotopes [9]. This assignment is very important to establish the decay of $^{127m}Ba(T_{1/2}=1.9$ seconds). Indeed, from the systematics, the lower levels in odd-A bariums are $1/2^{+}$ and $3/2^{+}$, the first one being the ground state. The (M1, E2) 56.2 keV transition is located between these states and the isomeric transition, 24.2 keV (M2) is placed between the $7/2^{-}$ and the $3/2^{+}$ states. The place of the 56.2 keV transition is confirmed by different other γ-γ coincidences and by the intensity balance.

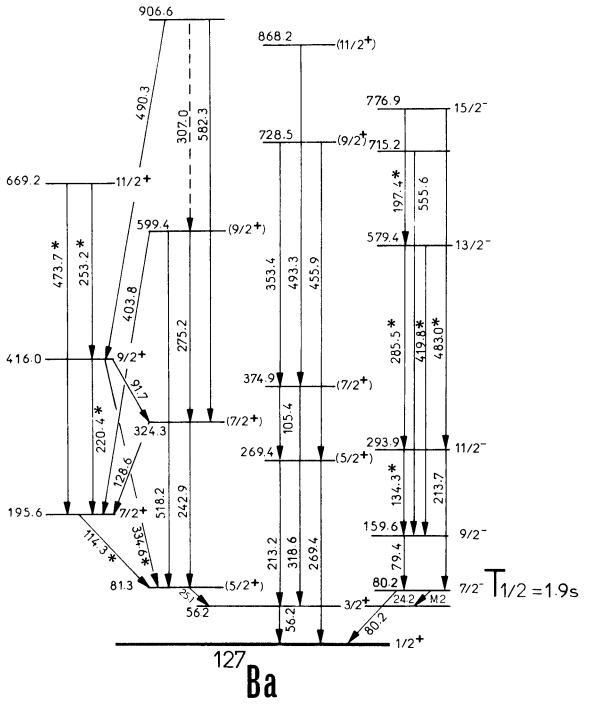

Fig.4 . Partial level scheme of ^{127}Ba fed by the ^{127}La decay.

Three positive-parity bands are fed from the ^{127}La decay. The one based on the $7/2^{+}$ level at 195.6 keV is the regular $g_{7/2}$ band structure observed in the $^{118}Sn(^{12}C, 3n)$ reaction. This structure is strongly connected with the one based on a level at 81.3 keV and deexcited by a 25.1 keV transition to the lower $3/2^{+}$ state (figure 6). As the multipolarity of the 114.3 keV transition has not been determined in the present work, the $(5/2^{+})$ assignment made for the level at 81.3 keV (figure 4) is only tentative. The strong connexion between the two rotational bands suggests that the base states $7/2^{+}$ and $(5/2^{+})$ are both originating from the same $g_{7/2}$

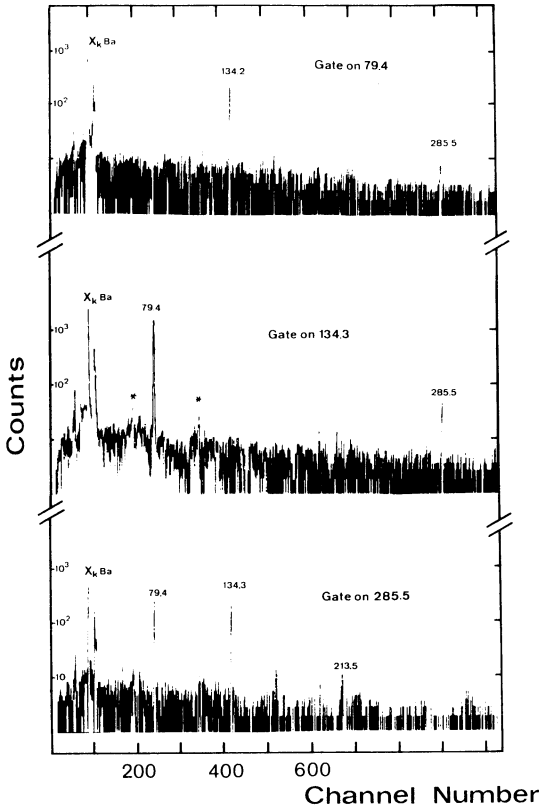

Figure 5 - γ-γ coincidence spectra which show the lower part of the negative parity band.

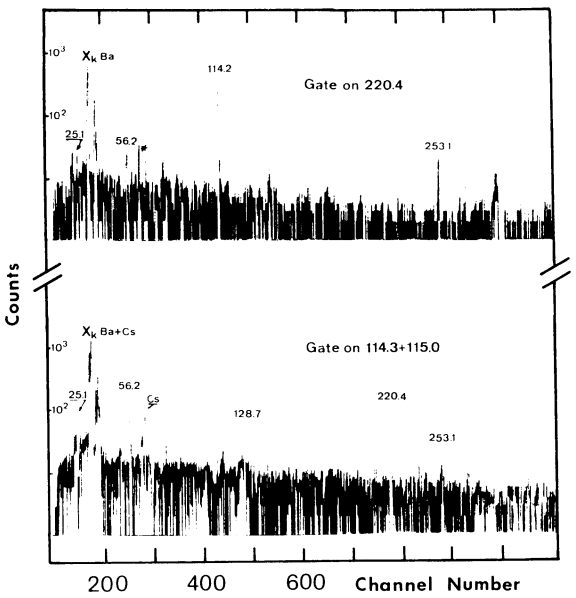

Figure 6 - γ-γ coincidence spectra which show the decay of the positive parity structure to the lower levels of ^{127}Ba.

shell. The third positive parity band is based on the $1/2^+$ state, but, as no multipolarities have been established up to now, the nature of this band cannot be discussed in details.

4. Discussion

From the present work several points are weel established in ^{127}Ba. Two different half-lives have been identified. The first one ($T_{1/2}$ = 13 minutes) is associated to the $1/2^+$ ground state while the second one ($T_{1/2}$ = 1.9 seconds) corresponds to the $7/2^-$ isomeric state. The systematics of the lower energy states in odd-bariums with $127 \leq A \leq 133$ is now well established and reported in figure 7.

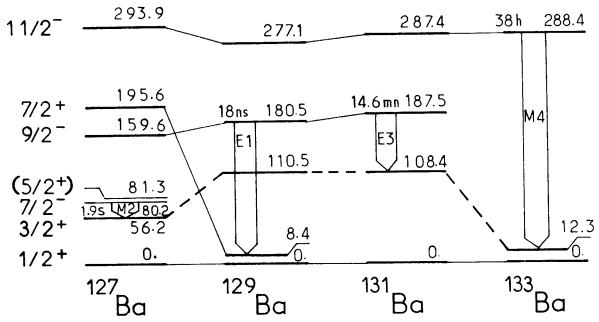

Figure 7 - Lower states in odd-A bariums.

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