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THE DECAY OF ^{124}Cs

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Résumé. — La désintégration du ^{124}Cs a été étudiée auprès du séparateur ISOLDE et un schéma des états excités du ^{124}Xe est proposé. Outre les niveaux des bandes fondamentales et quasi-gamma qui étaient déjà connus, on a observé les états 0^+ et 2^+ de la bande quasi-bêta à 1 268,7 et 1 628,3 keV respectivement.

Abstract. — The decay of ^{124}Cs has been investigated at the ISOLDE facility and a level scheme of ^{124}Xe is proposed. In addition to the previously known levels of the ground state and the quasi-gamma bands, the 0^+ and 2^+ states of the quasi-beta band have been observed at 1 268.7 and 1 628.3 keV respectively.

1. **Introduction.** — This work is a continuation of our investigation of light even xenon nuclei as populated in the decays of ^{118,120,122}Cs [1, 2]. Studies of the heavier nuclei namely the ^{126}Cs [3] and ^{128}Cs [4] decay schemes including the first levels of the quasi-gamma and beta bands have been recently reported. However, experimental data on the decay of ^{124}Cs are scanty. A few years ago, levels at 354 and 846 keV were suggested by Droste *et al.* [5]. Moreover, information on ^{124}Xe levels has been obtained from the ^{127}I(p, 4 nγ) reaction [6]. In that work, the ground state band and the quasi-beta band levels were proposed up to 8^+ and 5^+ respectively. On the other hand, no information is available on the second $K^\pi = 0^+$ band in ^{124}Xe. The present study was therefore undertaken with the aim of obtaining further knowledge on the decay of ^{124}Cs and especially on the quasi-beta band levels of ^{124}Xe.

2. **Experiment and results.** — The decay of ^{124}Cs has been investigated at the ISOLDE separator [7] on line with the CERN synchrocyclotron. The ^{124}Cs activity was produced by bombardment of a lanthanum target with 600 MeV protons. The experimental arrangement has been described in an earlier report [1].

The previously known half life of ^{124}Cs (31 s) was confirmed. No other ^{124}Cs activity with half life greater than five seconds was observed. The γ-rays ascribed to the decay of ^{124}Cs are reported in table I. The γ-ray spectrum is shown in figure 1. The conversion electron spectrum has been tentatively measured. However, only the lines K-354 and K-492 can be observed due to the large β^+ background associated with the very important β^+ branch towards the ground state. The corresponding conversion coefficients (19 ± 7 and $8 \pm 3 \times 10^{-3}$) are consistent with

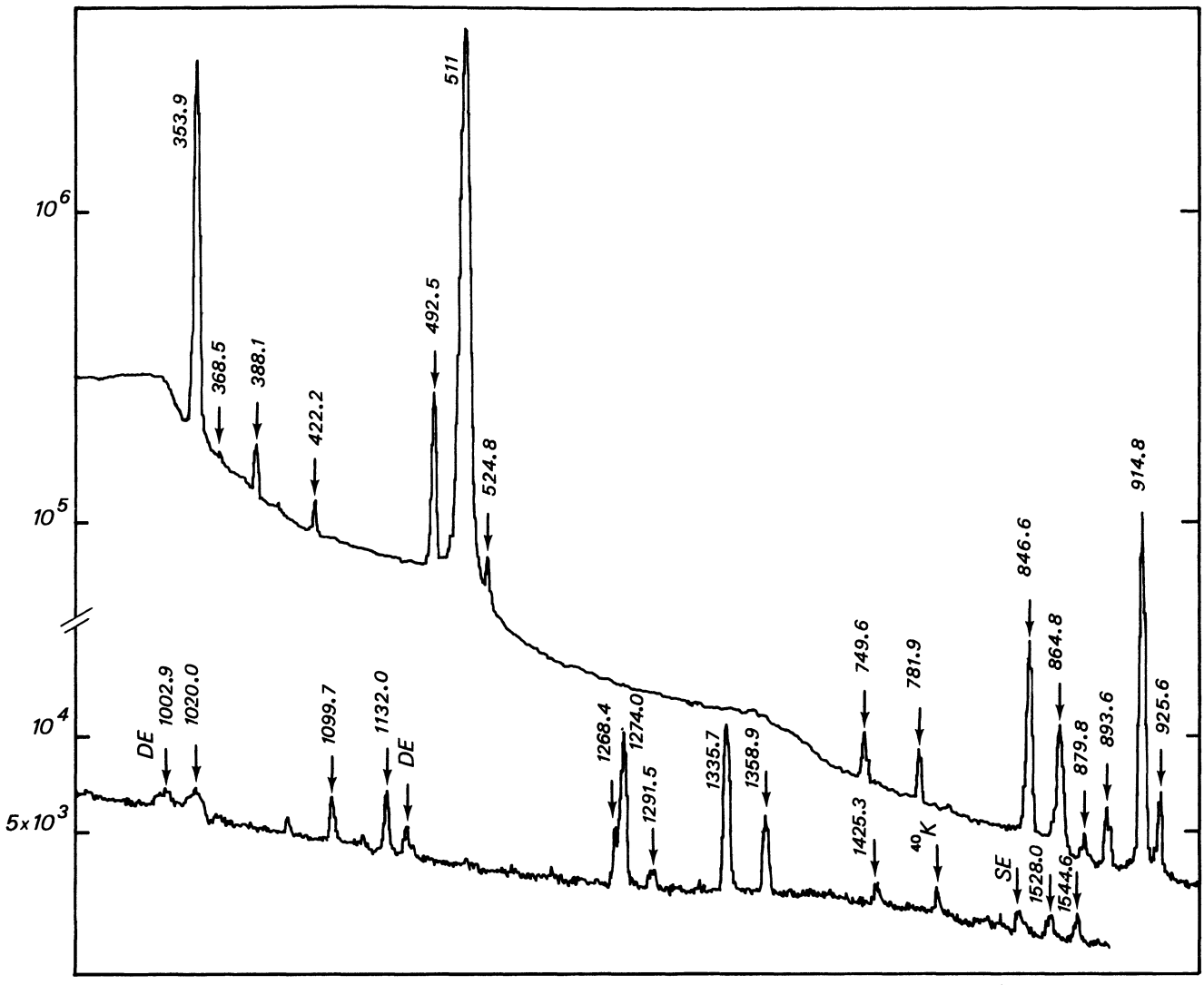

FIG. 1. — γ-ray spectrum associated with the mass 124. SE, DE = single, double escapement peak.

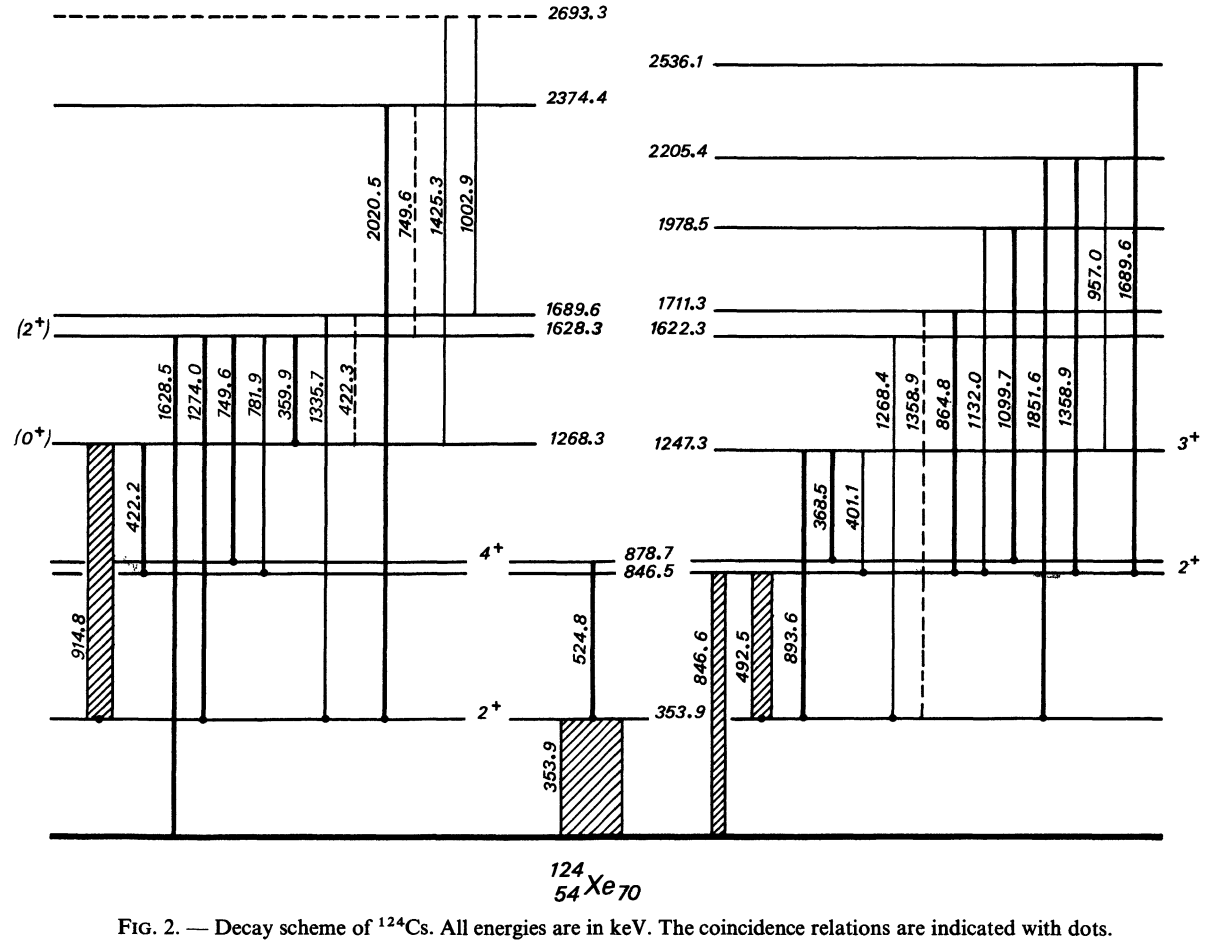

FIG. 2. — Decay scheme of ^{124}Cs. All energies are in keV. The coincidence relations are indicated with dots.

TABLE I

γ-ray transitions ascribed to the decay of 31 s ^{124}Cs

$E\gamma$ (keV)	$I\gamma$ (rel.)
353.9 (2)	100
359.9 (5)	0.6 (3)
368.5 (10)	0.2 (1)
380.7 (5)	0.10 (5)
388.1 (10)	1.80 (1.0)
401.1 (3)	0.22 (4)
422.2 (3)	0.92 (15)
492.5 (2)	9.1 (1.5)
524.8 (3)	1.0 (3)
749.6 (3)	0.50 (8)
781.9 (3)	0.50 (9)
846.6 (2)	3.0 (3)
864.8 (4)	1.0 (3)
866.4 (8)	0.57 (3)
879.8 (5)	0.17 (10)
893.6 (3)	0.40 (6)
914.8 (2)	10.0 (1.0)
925.1 (5)	0.60 (10)
957.0 (10)	0.03 (2)
1 002.9 (7)	0.08 (2)
1 020.0 (1.0)	0.10 (6)
1 073.6 (9)	0.07 (2)
1 099.7 (5)	0.24 (4)
1 132.0 (6)	0.36 (6)
1 268.4 (6)	0.23 (6)
1 274.0 (3)	1.10 (15)
1 291.5 (1.0)	0.08 (4)
1 335.7 (4)	1.2 (2)
1 358.9 (5)	0.40 (10)
1 425.3 (10)	0.06 (2)
1 528.0 (10)	0.08 (2)
1 544.5 (10)	0.09 (3)
1 628.5 (3)	2.4 (3)
1 673.4 (5)	0.08 (2)
1 689.6 (8)	1.4 (2)
1 759.3 (10)	0.08 (2)
1 851.6 (10)	0.70 (15)
1 979.5 (10)	0.25 (6)
2 020.5 (10)	1.60 (25)
2 126.0 (10)	2.0 (5)
2 382.0 (10)	0.4 (2)

the (E2, M1) multipolarity. The observed coincidence relations that were considered reliable are reported directly on the decay scheme. The decay scheme, based on available experimental evidence is given in figure 2. It includes the most intensive transitions of the γ-spectrum.

3. **The level scheme.** — The levels at 354 and 879 keV are interpreted as the first terms of the ground state band in accordance with previous investigations [5, 6]. The large intensity of the 511 keV peak suggests that most of the β^+ decay is feeding the ground state. The strong population of both 0^+ and 2^+ ground state levels is consistent with the measured spin : 1 [8] and the even parity of the ^{124}Cs ground state. The spin parity 1^+ is furthermore observed for all even cesium ground states from $A = 122$ up to $A = 130$.

Levels at 846 and 1 247 keV are interpreted as the 2^+ and 3^+ terms of the quasi-gamma band. In comparison to the other transitions de-exciting the 3^+ state, the 368 keV transition appears to be much more intense in the present experiment than in the ^{127}I(p, 4 nγ) reaction study [6]. The level at 1 711 keV which is strongly connected to the 2^+ level can be tentatively interpreted as a two-phonon state.

The 1 268 keV level is strongly connected to the 2^+ gs state but not to the 0^+ gs. As a matter of fact, a weak transition of 1 268.4 keV is observed in the γ-spectrum but the latter is clearly coincident with the 354 keV transition and was therefore placed elsewhere in the scheme. The 1 268 keV level can then be interpreted as a 0^+ state, the band head of the quasi-beta band.

A level at 1 628 keV which is connected at the same time to the 0^+ gs, 2^+ gs, 4^+ gs, 0^+ β and 2^+ γ states can be interpreted as the 2^+ member of this band. It should be noted that such a location of the 0^+ β state is in agreement with a rough extrapolation of the energy of even Xenon 0^+ β states from $A = 118$ to $A = 126$ as is shown in figure 3.

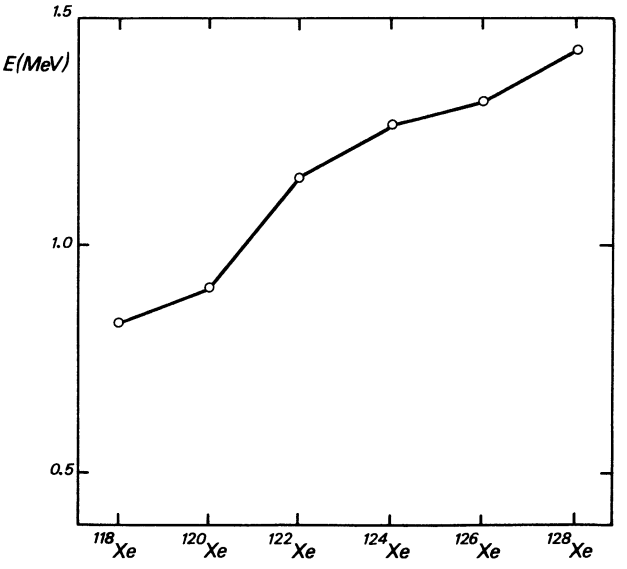

FIG. 3. — Systematic feature of the energy of the second 0^+ state in light even xenon nuclei.

4. **Discussion.** — Nuclear potential energy surfaces have been calculated according to the Strutinsky method for doubly even xenon from $A = 114$ to $A = 128$ ([1]). Two minima occur without pronounced differences on the oblate and prolate sides. However, slight indications are available which show a transition

([1]) Heyde, K., Private communication.

from prolate ($A \simeq$ 114-116) towards oblate ($A > 118$) shape. In this framework the nuclei ^{116,124}Xe, for which the energy difference $\Delta E = E(\varepsilon_2 = 0) - E(\varepsilon_2 \text{ min})$ is larger, seem to be rather soft against quadrupole vibrations. This accounts for the similarity between the excited level spectra of ^{124}Xe and ^{118,120,122}Xe [1]. The ^{124}Xe nucleus is expected to be weakly deformed and to exhibit both vibrational and rotational characteristics. It should be noted, however, that the xenon nuclei become more and more vibrational from $A = 124$. As a matter of fact, the ratio $B(\text{E2}, 2\,\gamma \rightarrow 0\,\text{g})/B(\text{E2}, 2\,\gamma \rightarrow 2\,\text{g})$ which is roughly stable for ^{118,122}Xe begins to decrease drastically from ^{124}Xe to ^{132}Xe. A structure of quasi-beta and quasi-gamma bands has been observed in all light even xenon nuclei. In every nucleus, the energy ratios $3\,\gamma \rightarrow 2\,\gamma/2\,\text{g} \rightarrow 0\,\text{g}$ and $2\,\beta \rightarrow 0\,\beta/2\,\text{g} \rightarrow 0\,\text{g}$ lie near the theoretical value (one) predicted by the rotational model. The decay patterns of the levels of the β-band seem to be similar in ^{126}Xe and ^{124}Xe. All this suggests that the properties of ^{124}Xe can be well inserted in the systematics of light even xenon.

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