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On-Line Spectroscopy of ^{134m,g}I

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Sources of mass-134 iodine have been produced in ^{235}U fission and studied on line in the Buenos Aires Isotope Separator On Line project using Ge(Li) and Si(Li) detectors. A transition of 272.2 ± 0.3 keV, with $T_{1/2} = 3.56 \pm 0.08$ min, $\alpha_K = 0.20 \pm 0.03$, and $K/L + \cdots = 2.6 \pm 0.3$, thus $E3(+ \leq 1\% M4)$ in character, was determined to be the transition depopulating the isomeric state in ^{134}I ($E_L - E_K = 28.4 \pm 0.2$ keV and K binding energy = 32.9 ± 0.6 keV). The β branching from this isomeric state to levels of ^{134}Xe amounts to (8 ± 6)%. γ-ray intensities following the ground-state decay of ^{134}I ($T_{1/2} = 53.2 \pm 0.2$ min) are given. Internal-conversion coefficients for 11 transitions have been measured ($10^4\alpha_K$): 135 keV, 2600 ± 500; 188 keV, 1300 ± 500; 236 keV, 700 ± 100; 406 keV, 110 ± 20; 433 keV, 150 ± 30; 541 keV, 60 ± 8; 596 keV, 70 ± 8; 622 keV, 52 ± 8; 628 keV, 25 ± 19; 847 keV, 18 ± 3; and 884 keV, 19 ± 4. Parities and angular momenta for levels of ^{134}Xe are proposed.

I. INTRODUCTION

Studying the decay of ^{134}I produced in ^{235}U fission Erten, Coryell, and Walters[1,2] realized that the activity of three of the low-lying transitions in ^{134}Xe (847, 884, and 1073 keV) increased at the beginning of their measurements with a component of about 3.8 min. From this they inferred the existence of an isomeric state in ^{134}I. Furthermore, they observed a γ transition of 273 keV and $T_{1/2} = 3.8 \pm 0.5$ min, but they could not decide whether it belonged to ^{134}I or to ^{134}Xe. In the same papers, the possibility of β feedings from ^{134m}I to levels in ^{134}Xe was discussed. Recently, Erten, Walter, and Coryell[3] have detected a 44.3-keV transition having the same half-life, and proposed a tentative scheme for the decay of the isomeric state: The 273-keV transition is taken as the time-setting ($E3$) isomeric transition and the 44.3-keV transition is placed in cascade with it, feeding the ground state. The proposed $J\pi$ for the isomeric level is (8-, 9-).

Our measurements were started in order to place the 273- and 44.3-keV transitions in ^{134}I or ^{134}Xe by means of a conclusive experiment and to determine the amount of β branching from the isomeric level. For the analysis of this β feeding we studied the relative γ-ray intensities in the decay of ^{134m,g}I in on-line, as compared with off-line, experiments. The off-line decay of 53-min ^{134g}I has recently been investigated by several authors who reported single[4-6] and coincidence[4,5] γ-ray measurements, as well as anisotropy determinations in γ-γ angular correlations.[5]

During the course of our work, our attention was called to a paper by Carraz *et al.*[7] dealing with the study of the 272-keV transition. Based principally on the absence of some β-γ and γ-γ coincidences, they deduced that this transition is the one depopulating the isomeric level in ^{134}I. However, our interpretation is that their experiments are not conclusive in locating the 272-keV transition in ^{134}I, since they do not discuss the possibility of the transition being linked to isomeric states in ^{134}Xe, which could also explain their experimental results. Isomeric levels in even-even nuclei of this A region have been reported.[8,9]

This work describes our measurements of γ transitions and internal-conversion electrons following the decay of ^{134m,g}I. Based on a positive experiment, we definitely set the 272.2-keV transition as an $E3$ isomeric transition in ^{134}I. We have also established the amount of β^- branching from the isomeric level. The measured conversion coefficients allow us to reduce the number of possible spins and parities proposed in Refs. 4 and 5 for the ^{134}Xe level scheme.

II. EXPERIMENTAL DETAILS AND DATA ANALYSIS

A. Production and Mass Separation of Fission Products

A sample of uranyl stearate containing 16 g of ^{235}U (90% enriched), placed in a stainless-steel container, was exposed to a flux of 10^8 thermal neutrons/cm^2 sec. Neutrons were obtained from the ^{7}Li(d,n)^{6}Be reaction, using 900-keV deuterons from a Cockcroft-Walton accelerator impinging on a 5-cm-diam natural-Li target. The current on the target was 1-2 mA. Paraffin was employed as moderator. A mixture of Xe and I was used as sweeping gas to introduce the fission products into the ion source of a mass separator (double-fo-

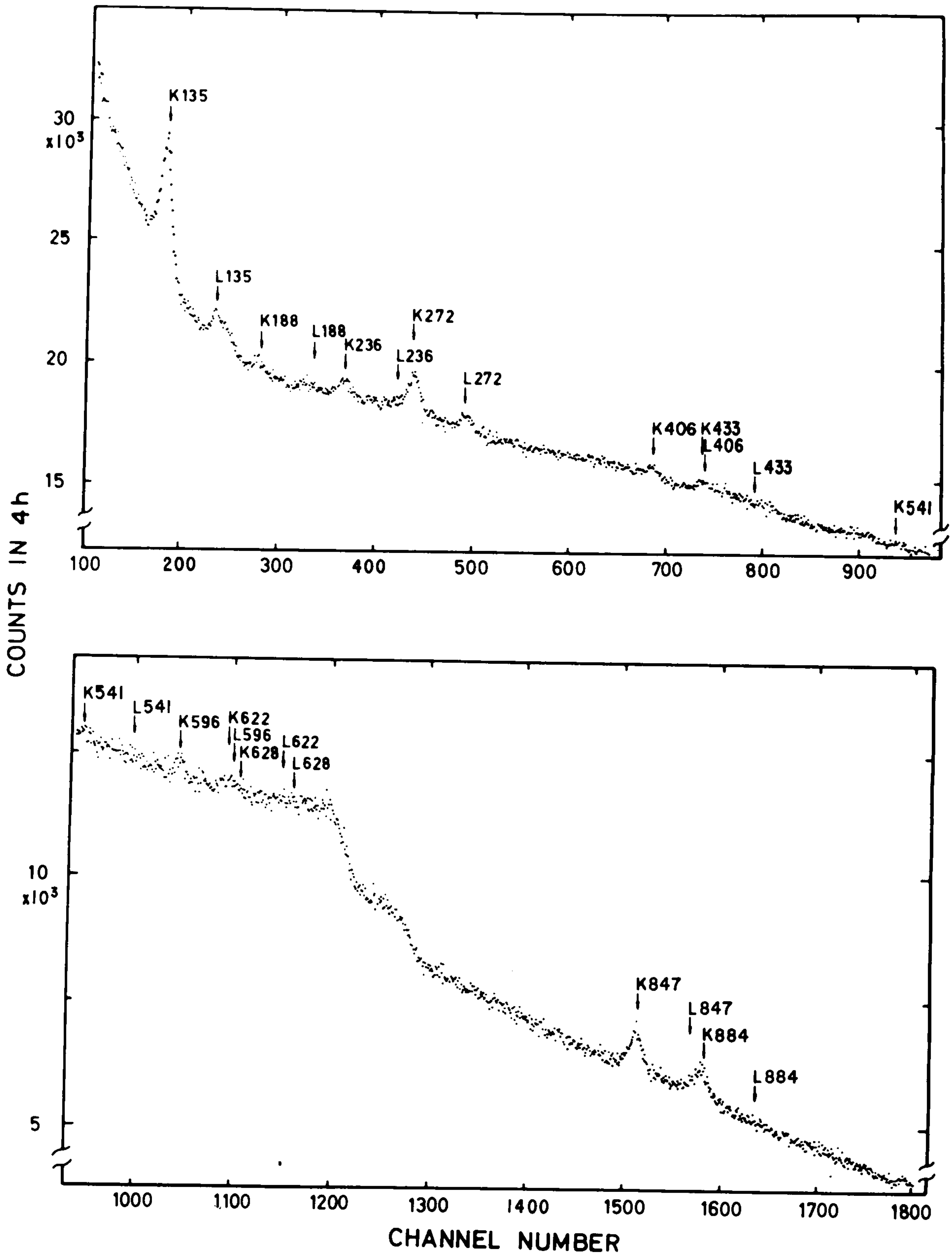

FIG. 1. On-line electron spectrum for the ^{134m,g}I decay. The lines corresponding to transitions for which we have measured conversion coefficients are identified. A Si(Li) detector of 1-cm^2 area and 3-mm depletion depth was used.

cusing Scandinavian type, 90° deflection). The images given by the separator were 5 mm in diameter (about 90% of the activity) and 17 mm from one image to the next. The mass corresponding to the central ray was extracted beyond the focal plane, in the vicinity of the detectors. Appropriate diaphragms and lead shielding prevented the radiations emitted by the neighboring masses from reaching the detection devices. Lead and boric acid were the principal shielding materials used to reduce (n, γ) reactions either in the detectors themselves or in other materials close to them. The activity was collected either on a fixed Al collector or on a moving Mylar tape. A detailed description of the setup will be published elsewhere.

B. γ-Ray Measurements

γ-ray spectra were measured with a Nuclear Diodes coaxial Ge(Li) detector of 35 cm^3 coupled to a cooled field-effect transistor preamplifier. Used with a model No. TC200 Tennelec amplifier it showed a resolution of 2.0 keV for the 1332-keV ^{60}Co peak. Daily variations of temperature did not affect this performance during periods of about two days. γ-ray energies of the most prominent transitions were measured against standard transitions using ^{88}Y, ^{203}Hg, ^{208}Tl, and ^{226}Ra sources, and then used for internal calibration.

The efficiency calibration about 250 keV was made applying the method of cascades[10] with the following standard sources: $^{22,24}Na$, ^{88}Y, $^{108,110m}Ag$, and ^{208}Tl; it was extended to lower energies by normalizing the intensities of ^{75}Se and ^{180m}Hf decays at, respectively, 400 and 444 keV. The calibration curve thus obtained is reliable to ±3% in the energy range 90–200 keV and to ±2% from 200 keV to 2.7 MeV.

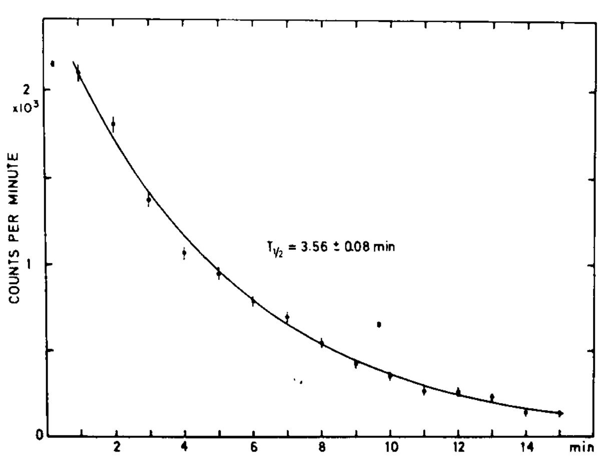

FIG. 2. Exponential fit to the decaying intensity of the 272.2-keV transition.

The peak areas were obtained using the GAMANL [11] computer program. The data were recorded in an analyzer system provided with two 4096-channel analog-to-digital converters and several readout peripherals under control of a small Hewlett-Packard computer having a 16 000 memory. The software supplied with the system was suitably modified by us for our requirements. Additional software was developed at our laboratory.

C. Internal-Conversion Electron Measurements

A 1-cm^2 × 3-mm-depletion-depth Simtec Si(Li) detector was used to detect conversion electrons as well as x rays. When operated at liquid-N_2 temperature with a Tennelec preamplifier and a model No. 410 ORTEC amplifier it showed a resolution of 7.0 keV for the 482- and 976-keV lines of ^{207}Bi. The relative efficiency was obtained by measuring known internal-conversion coefficients (^{135}Xe off line, ^{135}I on line, and the standards ^{139}Ba, ^{137}Cs, ^{203}Hg, and ^{207}Bi). In this way processes such as summing are taken into account. Uncertainties in the knowledge of the "conversion-coefficient curve" amount to ±8%. Figure 1 shows an on-line electron spectrum of $^{134m,g}I$ activity, taken during 4 h of irradiation.

III. EXPERIMENTAL RESULTS

A. Isomeric Level in ^{134}I

The conversion-electron measurements for the 272-keV transition gave $\alpha_K = 0.20 \pm 0.03$ and $K/L + \cdots = 2.6 \pm 0.3$, thus leading to an $E3$ ($+ \leq 1\%$ $M4$) multipolarity. By γ-ray measurements, we determined its energy to be 272.2 ± 0.3 keV. From this value and the energies of the K and L conversion lines we obtained $E_L - E_K = 28.4 \pm 0.2$ keV and the K binding energy $B_K = 32.9 \pm 0.6$ keV, which place the transition as the isomeric transition in ^{134m}I.

A γ transition of 44 keV, most probably the one reported in Refs. 3 and 7, was observed with the Si(Li) detector, although very poorly mainly because of the high neutron-induced background. In qualitative x-γ coincidence measurements using Si(Li) and Ge(Li) detectors and a conventional slow ($2\tau \approx 10^{-6}$ sec) coincidence circuit, the coincidence x_K–272.2-keV is so clearly seen that there remains no doubt about the existence of a highly converted transition in cascade with the 272.2-keV transition. From the singles γ-ray spectra, it follows that the crossover transition, if it exists, can have an intensity not greater than 5% of the intensity of the isomeric transition.

Using the moving collector, the shorter half-life characterizing the isomeric transition was

TABLE I. Energies and relative γ-ray intensities following ^{134g}I decay.

Measured E_γ (keV)		Relative intensity	
Present work	Winn *et al.* (Ref. 4)	Present work	Winn *et al.* (Ref. 4)
135.4 ± 0.2	135.55 ± 0.15	4.12 ± 0.14	4.97 ± 0.11
139.3 ± 0.3	138.5 ± 0.5	0.83 ± 0.04	0.88 ± 0.12
162.5 ± 0.2	162.65 ± 0.5	0.28 ± 0.02	0.38 ± 0.04
188.3 ± 0.4	188.75 ± 0.4	0.84 ± 0.05	0.92 ± 0.06
217.9 ± 0.3	216.95 ± 0.5	0.20 ± 0.02	0.30 ± 0.05
235.5 ± 0.2	235.3 ± 0.4	2.10 ± 0.06	2.60 ± 0.16
279.0 ± 0.6	279.0 ± 0.7	0.17 ± 0.09	0.16 ± 0.05
313.1 ± 0.4	311.0 ± 0.7	0.14 ± 0.04	0.10 ± 0.05
319.7 ± 0.3	319.85 ± 0.5	0.45 ± 0.02	0.48 ± 0.07
351.3 ± 0.3	350.5 ± 1.0	0.34 ± 0.03	0.53 ± 0.07
405.5 ± 0.2	405.3 ± 0.25	7.59 ± 0.16	7.71 ± 0.15
411.4 ± 0.3	410.9 ± 0.7	0.58 ± 0.03	0.56 ± 0.10
433.4 ± 0.2	433.2 ± 0.2	4.24 ± 0.10	4.44 ± 0.12
459.3 ± 0.3	458.75 ± 0.15	1.36 ± 0.05	1.49 ± 0.28
489.1 ± 0.3	488.7 ± 0.3	1.60 ± 0.06	1.38 ± 0.11
514.4 ± 0.3	514.4 ± 0.3	2.24 ± 0.22	2.27 ± 0.13
541.1 ± 0.2	540.65 ± 0.25	8.07 ± 0.20	7.88 ± 0.23
565.6 ± 0.3	565.3 ± 0.4	1.14 ± 0.06	0.92 ± 0.12
570.9 ± 0.3	571.2 ± 0.7	0.50 ± 0.15	0.35 ± 0.14
595.5 ± 0.2	595.2 ± 0.2	11.72 ± 0.25	11.52 ± 0.18
622.0 ± 0.2	621.6 ± 0.2	11.40 ± 0.25	11.07 ± 0.21
628.4 ± 0.3	627.85 ± 0.35	2.24 ± 0.07	2.21 ± 0.20
677.6 ± 0.2	677.4 ± 0.5	7.97 ± 0.24	7.84 ± 0.78
730.9 ± 0.3	730.5 ± 0.3	1.94 ± 0.07	1.76 ± 0.12
739.2 ± 0.3	739.2 ± 0.4	0.63 ± 0.04	0.80 ± 0.15
766.9 ± 0.3	766.4 ± 0.2	4.26 ± 0.12	4.45 ± 0.17
	784.85 ± 0.5	≤0.3	0.42 ± 0.10
817.2 ± 0.3	816.1 ± 0.5	0.75 ± 0.04	0.56 ± 0.11
836.7 ± 0.4	837.3 ± 0.5	0.65 ± 0.05	0.66 ± 0.13
847.2 ± 0.2	846.95 ± 0.15	100.00 ± 2.10 [a]	100.00
857.7 ± 0.3	857.25 ± 0.2	6.95 ± 0.22	6.73 ± 0.16
884.3 ± 0.2	884.05 ± 0.15	67.53 ± 1.42	68.12 ± 0.60
948.2 ± 0.3	948.0 ± 0.4	4.26 ± 0.12	4.02 ± 0.20
966.6 ± 0.4	967.6 ± 0.4	0.47 ± 0.05	0.29 ± 0.15
974.9 ± 0.3	974.6 ± 0.2	5.08 ± 0.13	4.96 ± 0.25
1040.6 ± 0.3	1039.5 ± 0.6	1.94 ± 0.07	2.32 ± 0.10
1072.9 ± 0.2	1072.85 ± 0.15	15.55 ± 0.35	15.63 ± 0.16
1099.1 ± 0.3	1100.8 ± 0.5	1.11 ± 0.05	0.71 ± 0.11
1103.6 ± 0.3	1102.4 ± 0.7	0.88 ± 0.05	1.06 ± 0.20
1136.4 ± 0.2	1136.6 ± 0.4	10.09 ± 0.24	8.52 ± 0.26
1159.5 ± 0.4	1159.9 ± 0.5	0.37 ± 0.06	0.30 ± 0.07
1191.2 ± 0.4	1191.6 ± 0.7	0.28 ± 0.08	0.21 ± 0.06
1269.9 ± 0.4	1270.15 ± 0.3	0.61 ± 0.05	0.49 ± 0.10
1322.5 ± 0.6	1323.0 ± 0.9	0.19 ± 0.04	0.14 ± 0.07
1336.6 ± 0.6	1336.9 ± 0.9	0.14 ± 0.03	0.16 ± 0.08
1353.8 ± 0.4	1353.7 ± 0.7	0.41 ± 0.07	0.37 ± 0.06
1428.7 ± 1.2	1429.6 ± 0.9	≈0.2	0.17 ± 0.08
1455.5 ± 0.4	1456.7 ± 0.7	2.07 ± 0.08	2.82 ± 0.13
1470.0 ± 0.4	1470.6 ± 0.6	0.77 ± 0.06	0.79 ± 0.09
1542.2 ± 0.4	1542.9 ± 1.0	0.48 ± 0.08	0.54 ± 0.08
1614.0 ± 0.3	1613.7 ± 0.5	4.25 ± 0.13	4.80 ± 0.32
1629.2 ± 0.7	1628.9 ± 1.5	0.14 ± 0.03	0.22 ± 0.06
1644.8 ± 0.4	1643.8 ± 1.0	0.44 ± 0.07	0.38 ± 0.06
1656.1 ± 0.7	1654.6 ± 1.5	0.16 ± 0.03	0.16 ± 0.04
1741.5 ± 0.5	1741.1 ± 0.7	2.46 ± 0.09	3.00 ± 0.22
1806.8 ± 0.3	1806.1 ± 0.8	5.52 ± 0.17	6.03 ± 0.10
	1870.3 ± 0.9	≤0.15	0.06 ± 0.03

TABLE I *(Continued)*

Measured E_γ (keV) Present work	Winn *et al.* (Ref. 4)	Relative intensity Present work	Winn *et al.* (Ref. 4)
1926.0 ± 0.7	1927.5 ± 1.8	0.18 ± 0.06	0.20 ± 0.07
2021.2 ± 0.7	2021.2 ± 1.0	0.17 ± 0.06	0.22 ± 0.04
2158.5 ± 0.7	2160.7 ± 1.5	0.15 ± 0.05	0.23 ± 0.03
2262.0 ± 0.8	2262.4 ± 1.5	0.12 ± 0.03	0.06 ± 0.03
2312.2 ± 0.8	2313.0 ± 1.3	0.22 ± 0.05	0.22 ± 0.03
2410.2 ± 0.8	2409.0 ± 1.4	0.07 ± 0.02	0.10 ± 0.02
2452.9 ± 0.8	2453.3 ± 1.3	0.07 ± 0.03	0.05 ± 0.02
2469.4 ± 0.8	2467.4 ± 1.3	0.12 ± 0.04	0.12 ± 0.02
	2512.8 ± 1.6		0.06 ± 0.02
	2628.6 ± 1.8		0.07 ± 0.02
	2646.0 ± 2.0		≈0.02

[a]The error stated for the intensity normalized to 100.00 has not been included in the errors of the other intensities.

favored, compared with the 53-min ground-state decay. From a number of decay spectra the half-life of the isomeric transition was obtained applying Peierls's method. The value found was $T_{1/2} = 3.56 \pm 0.08$ min (Fig. 2). No other transition with this pure half-life was observed above 100 keV. As the 233-keV transition deexciting the 0.29-sec isomeric 7− level[4] in ^{134}Xe was not observed, this level certainly is not fed significantly from ^{134m}I, as already pointed out in Ref. 7.

The evolution of the activity of the 272-keV transition and of the 847-keV γ ray depopulating the first 2+ state in ^{134}Xe was followed immediately after switching off the on-line collection. The amount of the 3.56-min component in the decay of the 847-keV transition was obtained with a rather large error, due to the strong 53-min component present. Comparing this amount with the well-determined intensity of the 272-keV transition, we deduce that $(92 \pm 6)\%$ of the activity of the isomeric level proceeds through the isomeric transition; consequently, the β branching to ^{134}Xe levels is $(8 \pm 6)\%$. The variations of relative intensities in ^{134}Xe γ transitions obtained in on-line measurements were much smaller than in off-line ones. However, based on the ^{134}Xe level scheme proposed in Ref. 4, we conclude that in on-line experiments the intensities of γ rays depopulating the 2867.3- and 2352.8-keV levels become greater relative to those deexciting other levels, the evidence being less conclusive in the latter case.

The activity on the collector showed no trace of any transitions due to ^{134}Te decay. The decay of ^{134}I was followed after switching off the neutron source while proceeding with the extraction of activity from the uranium container and with its collection. It was clearly noticeable that, within the container, ^{134}Te was feeding ^{134g}I. However, no such feeding of ^{134m}I was detectable; this is in agreement with the fact that the 272-keV transition is not detected[6] in the decay of ^{134}Te.

B. Ground-State Decay of ^{134}I

In Table I we compare our γ-ray energies and relative intensities with those reported by Winn and Sarantites[4] as following the ground-state iodine-134 decay. We did not check the half-lives of all these transitions; only the most intense were measured. The agreement of the energies is very good. For relative intensities, the agreement is somewhat worse, even for the rather important 135-, 236-, 1041-, 1136-, 1456-, and 1807-keV γ rays.

For the 135-keV transition the discrepancy may arise from the fact that owing to our better energy resolution, we could resolve it clearly from the 139-keV γ ray. Winn and Sarantites could not resolve the 1136-keV transition from a transition

TABLE II. Results from conversion-electron measurements in ^{134g}I decay.

E_γ (keV)	$10^4\alpha_K$	$K/L+\cdots$	Proposed multipolarity
135.4	2600 ± 500		$M1(+E2)$
139.3	≤ 10 000		$E2, M1, E1$
188.3	1300 ± 500		$M1$–$E2$
235.5	700 ± 100	6.1 ± 0.7	$M1(+E2)$
405.5	110 ± 20		$E2$
433.4	150 ± 30		$M1(+E2)$
541.1	60 ± 8		$E2(+M1)$
595.5	70 ± 8		$M1$
622.0	52 ± 8		$M1$–$E2$
628.4	25 ± 19		$M1$–$E2$
677.6	≤65		$M1, E2, E1$
847.2	18 ± 3	7.5 ± 0.6	$E2$
884.3	19 ± 4		$E2(+M1)$
1072.9	≤18		$M1, E2, E1$

in ^{135}Xe, which is absent in our experiments. The larger intensity quoted by these authors for the 1457-keV γ ray might possibly be due to incomplete correction for the 1460-keV ^{40}K natural-background contribution (the spectrum reproduced in their paper shows a 2613-keV background line, which we suggest could arise from Th*B*, usually also present in natural background). Finally, we have been unable to detect the 785- and 1870-keV γ rays reported by Winn *et al.* (the energy of the first one coincides with that of the double-escape peak corresponding to the 1807-keV transition).

During the present experiments, which exclude the presence of other iodine isotopes (and, as mentioned above, of ^{134}Te), the half-life of ^{134g}I was measured following the decay of the 847-keV transition after switching off the collection. The value was found to be 53.2 ± 0.2 min.

Table II gives the measured conversion coefficients of 11 transitions in ^{134}Xe, as well as the dominant multipolarities. In Fig. 3 we show our experimental results, together with the theoretical[12] *K* conversion curves. For the α_K of the pure *E*2 transition of 847 keV we obtained $(18 \pm 3) \times 10^{-4}$, to be compared with the theoretical value of 20×10^{-4}.

IV. SPIN-PARITY ASSIGNMENTS FOR ^{134}Xe LEVELS

Winn *et al.*[4] proposed possible angular momenta and parities for the ^{134}Xe levels, based on deduced log*ft* values and on the $J\pi$ values of the levels populated in their decay. From similar arguments, Takekoshi, Umezawa, and Suzuki[5] independently suggested a somewhat broader range of possible spins and parities. Moreover, these authors[5] were able, through anisotropy measurements, to give definite assignments of 2 and 4 to the 847- and 1731-keV levels, respectively. On this basis, by applying our measured *K* conversion coefficients to the reported[4,5] level schemes, we could restrict the proposed parity possibilities to those shown in the partial level scheme in Fig. 4.

Negative parity was eliminated for the 1920-, 2137-, 2272-, and 2353-keV levels because of the *M*1-*E*2 multipolarity of the transitions connecting them with the 4+ 1731-keV level and to additional support from the multipolarities of the 135- and 433-keV transitions. Consequently, in disagreement with the suggestion by Winn *et al.*, the 2137-keV level is not analogous to the 5− levels observed in ^{136}Ba and ^{138}Ce. On the other hand, the

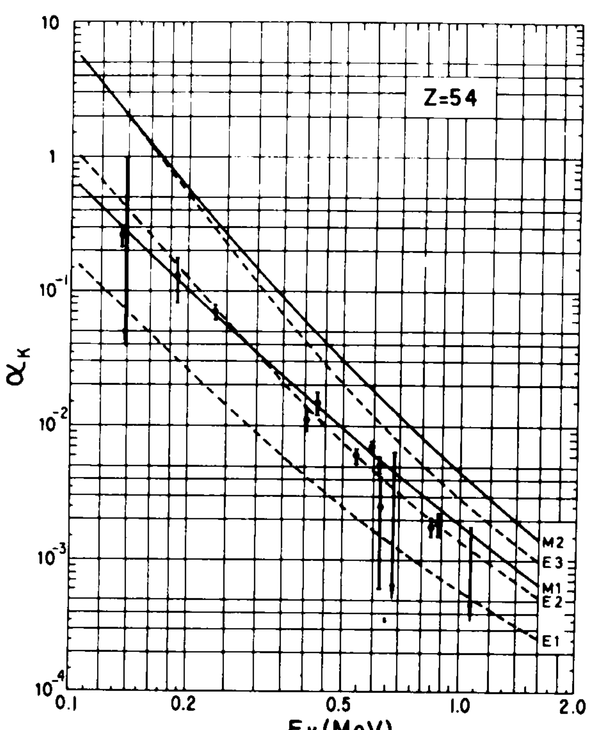

FIG. 3. Plot of theoretical (Ref. 12) and measured *K* conversion coefficients corresponding to ^{134g}I decay.

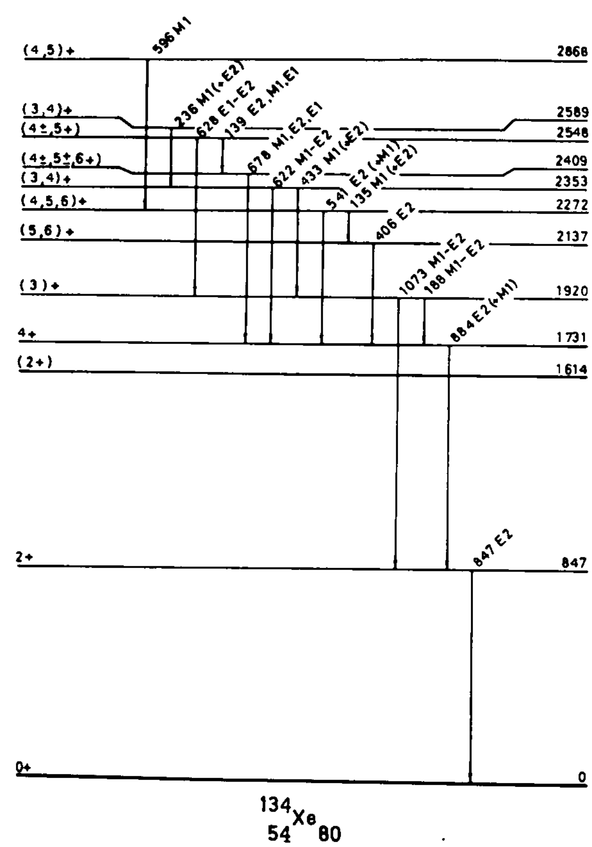

FIG. 4. Partial level scheme, based on Refs. 4 and 5, with our proposed spins and parities. Shown are the transitions whose multipolarities have been determined in the present work and those levels between which they proceeded. The 1614-keV level is included for reasons of completeness.

multipolarities of the 235- and 596-keV transitions give additional experimental evidence for the positive parity proposed by Winn *et al.* for the 2589- and 2868-keV levels.

The anisotropy measurements by Takekoshi *et al.*[5] also led to spin (4, 5) for the 2868-keV level and to spin (2, 3) for the 1920-keV level. For the latter, from log *ft* values and relative intensities of the deexciting transitions, Winn *et al.* proposed (3±, 4+), while Takekoshi *et al.* proposed $J = (3)$. These results agree with the (2, 3, 4)+ possibilities allowed by our determination of conversion coefficients. Thus, (3)+ appears to be the most reasonable assignment for the 1920-keV level. On the other hand, Winn *et al.* pointed out that a 4+ assignment for this level could help to explain, by a small branch decaying to it, a discrepancy in the retardation factor of the decay of the 7− state in ^{134}Xe, as compared with the factors corresponding to similar states in the neighboring isotones. Although they clearly state that they did not obtain conclusive evidence for identifying the 1920-keV level as analogous to the low-lying 4+ levels of the neighboring $N = 80$ isotones, they point out that if this level were 4+, it would smoothly fit into the systematic energy trend of those levels. However, a plot of the E_4^1/E_2^1 energy ratio[9,13–16] as a function of Z in the N region of interest (Fig. 5) shows that this energy trend is much better satisfied by the 1731-keV 4+ level than by the 1920-keV level. Additional experimental support for the (3)+ assignment to the 1920-keV level could be obtained

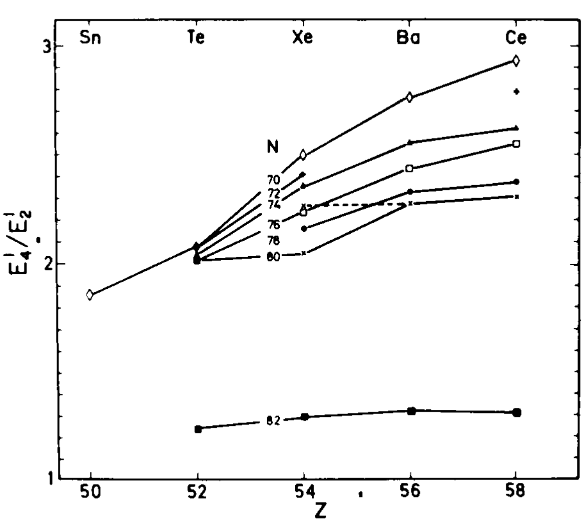

FIG. 5. Systematic behavior of the ratio E_4^1/E_2^1 as a function of proton number in the $N = 70$–82 region. The data have been taken mainly from Refs. 13 and 14; for ^{132,134}Te from Ref. 15; for ^{136}Xe from Ref. 9; and for ^{138}Ba from Ref. 16. The dashed curve is obtained when the 1920-keV level instead of the 1731-keV level is taken as the first 4+ level in ^{134}Xe.

by determining the multipolarity of the 1073-keV transition to be at least partially $M1$. Unfortunately, our present setup is not sensitive enough to decide between $M1$ and $E2$.

Based on the $E2$ multipolarity of the 406-keV transition, we have removed the spin-4 possibility[4] for the 2137-keV level, leaving $J\pi = (5, 6)+$ for this level. Taking the level to be 6+, the corresponding E_6^1/E_2^1 energy ratio fits smoothly into the general trend of this ratio for Xe isotopes. However, as we have considered that the most reasonable assignment for the 1920-keV level is (3)+, the 218-keV transition placed by coincidence measurements[4] as linking the 2137- and 1920-keV levels would have to be of $M3$ or higher multipolarity. In our conversion-electron spectra, the K 218-keV line is not resolved from the L 188-keV line. In spite of that, assuming that all of the electron intensity available at this energy belongs to the K 218-keV line the possibility of $M3$ or higher multipolarity for this transition is excluded. Consequently, a (5)+ assignment seems to be more probable for the 2137-keV level. The only similar level we have found reported[13] in this Z-N region is the 1950-keV (5)+ level in ^{130}Xe.

For the 2272-keV level Winn *et al.* proposed spins (4, 5, 6). The first value is, however, improbable because of the $E2(+M1)$ multipolarity of the 541-keV transition linking it to the 1731-keV 4+ level. If the level is considered to be 6+, the corresponding E_6^1/E_2^1 ratio again fits rather smoothly into the general trend of this ratio for Xe isotopes.

The same authors proposed also spins (4, 5, 6) for the 2548-keV level. The $E1$-$E2$ multipolarity we determined for the 628-keV transition linking this level with the (3)+ 1920-keV level eliminates the spin-6 possibility.

V. CONCLUSIONS

In the present work we have performed conversion-electron measurements in the decay of ^{134m,g}I not reported previously. In this way we have been able to establish that a 272.2 ± 0.3-keV transition takes place between levels of iodine. Its K conversion coefficient and $K/L+\cdots$ ratio correspond to an $E3$ (+ ≤1% $M4$) transition. As iodine-134 has 81 neutrons, the measured half-life of 3.56 ± 0.08 min and the energy of the transition give a significant indication of the behavior of $E3$ transitions[17] near the $N = 82$ closed shell ($\log_{10}\tau_\gamma A^2 E_\gamma{}^7 = 2.7$). The amount of β branching in the decay of ^{134m}I has been established to be $(8 \pm 6)\%$.

Our measured K conversion coefficients allowed us to restrict the proposed[4] possible spin-parity assignments for ^{134}Xe levels to those shown on the partial level scheme in Fig. 4. Negative parity has been eliminated for the 1920-, 2137-, 2272-, and 2353-keV levels. From previous[4,5] assignments, not contradicted by our α_K determinations, the 1920-keV level most probably has $J\pi = (3)+$. The spin-4 possibility[4] has been removed from the 2137-keV level which remains as (5, 6), although 5 appears to be more probable. Based on the (3)+ assignment of the 1920-keV level, spin 6 has been disregarded as a possibility[4] for the level at 2548 keV.

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[1]H. Erten and C. D. Coryell, Massachusetts Institute of Technology Report No. MIT-905-133, 1968 (unpublished), p. 14.

[2]H. N. Erten, C. D. Coryell, and W. B. Walters, Bull. Am. Phys. Soc. 14, 1255 (1968); and private communication.

[3]H. N. Erten, W. B. Walters, and C. D. Coryell, Massachusetts Institute of Technology Report No. MIT-905-154, 1969 (unpublished), p. 11.

[4]W. G. Winn and D. G. Sarantites, Phys. Rev. 184, 1188 (1969).

[5]E. Takekoshi, H. Umezawa, and T. Suzuki, Nucl. Phys. A133, 493 (1969).

[6]V. Berg, K. Fransson, and C. E. Bemis, Arkiv Fysik 37, 203 (1968).

[7]L. Carraz, J. Blachot, E. Monnand, and A. Moussa, Compt. Rend. B270, 358 (1970).

[8]J. Kantele and O. Tannila, Nucl. Data A4, 359 (1968).

[9]E. Monnand, J. Blachot, L. C. Carraz, and A. Moussa, European Organization for Nuclear Research Report No. CERN 70-30 (unpublished), p. 1119.

[10]W. R. Kane and M. A. Mariscotti, Nucl. Instr. Methods 56, 189 (1967).

[11]T. Inouye, T. Harper, and C. Rasmussen, Nucl. Instr. Methods 67, 125 (1969).

[12]R. S. Hager and E. C. Seltzer, Nucl. Data A4, 1 (1968).

[13]C. M. Lederer, J. M. Hollander, and I. Perlman, *Table of Isotopes* (John Wiley & Sons, Inc., New York, 1967).

[14]M. A. J. Mariscotti, G. Scharff-Goldhaber, and B. Buck, Phys. Rev. 178, 1864 (1969).

[15]J. B. Wilhelmy, S. G. Thompson, R. C. Jared, and E. Cheifetz, Phys. Rev. Letters 25, 1122 (1970).

[16]M. A. J. Mariscotti, W. Gelletly, J. A. Moragues, and W. R. Kane, Phys. Rev. 174, 1485 (1968).

[17]M. Goldhaber and A. N. Sunyar, in *Alpha-, Beta-, and Gamma-Ray Spectroscopy*, edited by K. Siegbahn (North-Holland Publishing Company, Amsterdam, The Netherlands, 1965), p. 941.