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EXCITED STATES OF XENON-130 POPULATED BY BETA DECAY

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ABSTRACT

Gamma rays emitted in the beta decay of 5^- ^{130}I and 1^+ ^{130}Cs have been studied with Ge(Li) and NaI(Tl) spectrometers. Twenty-four transitions were observed in the decay of ^{130}I, and 16 were observed in the decay of ^{130}Cs. From the gamma-ray singles spectra and from coincidence studies, the following excited levels of ^{130}Xe have been deduced: 536.1 (2^+), 1122.1 (2^+), 1204.5 (4^+), 1785.9, 1793.5, 1800.1, 1808.1, 1943.9 (5^+), 2016.1, 2150.6, 2171.3, 2223.3, 2242.8, 2361.8 (6^+), 2427.0, 2532.3, 2608.6, and 2752.3 keV. No evidence has been found for the population of a possible 0^+ "vibrational triplet" member at about twice the energy of the first excited state.

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SUMMARY

Gamma rays emitted in the beta decay of 5^- iodine-130 (^{130}I) and 1^+ cesium-130 (^{130}Cs) have been studied with Ge(Li) and NaI(Tl) spectrometers. Twenty-four transitions were observed in the decay of ^{130}I, and 16 were observed in the decay of ^{130}Cs. From the gamma-ray singles spectra and from coincidence studies, the following excited levels of xenon-130 (^{130}Xe) have been deduced: 536.1 (2^+), 1122.1 (2^+), 1204.5 (4^+), 1785.9, 1793.5, 1800.1, 1808.1, 1943.9 (5^+), 2016.1, 2150.6, 2171.3, 2223.3, 2242.8, 2361.8 (6^+), 2427.0, 2532.3, 2608.6, and 2752.3 keV. No evidence has been found for the population of a possible 0^+ "vibrational triplet" member at about twice the energy of the first excited state.

INTRODUCTION

A hydrodynamical model (refs. 1 to 3) has been used to describe the nature of the low lying energy levels in near-spherical, even-even nuclei. According to this model, these nuclei may undergo nearly harmonic surface oscillations analogous to the motions of a liquid drop. Furthermore, if these oscillations are assumed to be in quadrupole shape, then the second excited state with two phonons present should be a 0^+ - 2^+ - 4^+ triplet of states at about twice the energy of the one-phonon first excited state. Many even-even nuclei do show some of these levels but very few have been found to have all three members of the predicted triplet.

The present study of the beta decay of iodine-130 and cesium-130 (^{130}I and ^{130}Cs) has been undertaken to determine more completely the level structure of the daughter nucleus xenon-130 (^{130}Xe). Because of its proximity to the closed shells at 50 protons and

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82 neutrons, ^{130}Xe with 54 protons and 76 neutrons would be expected to be nearly spherical. It is convenient for study because its excited states are populated in the beta decay of 5^- ^{130}I and 1^+ ^{130}Cs. Therefore, if ^{130}Xe possesses a 0^+ - 2^+ - 4^+ triplet of states, all three of these states should be populated.

Both 4^+ (ref. 4) and "0^+ or 2^+" (ref. 5) excited states of ^{130}Xe have already been reported at about twice the energy of the first excited state. However, after observing gamma rays emitted in (α, Xn) reactions on separated tellurium (Te) isotopes, Morinaga and Lark (ref. 6) deduced the existence of a 0^+, 2^+, 4^+, 6^+, 8^+ band of states of ^{130}Xe, which they interpreted as resembling the energy level structure of a deformed rotor. A later paper by Betigeri and Morinaga (ref. 7) reported excitation of an additional (2^+) state at 1126 keV by means of the (^{3}He, 3n) reaction on ^{130}Te.

EXPERIMENTAL PROCEDURE

Source Preparation

Sources of 12.5-hour ^{130}I were prepared for the present study by neutron capture in ^{129}I. As an extra purification step, iodine was chemically removed from the commercially obtained sources, either by sublimation or by precipitation as silver iodide. The sources were studied for as long as a week to make sure that none of the previously unreported gamma rays was due to a long-lived contaminant. One source did contain a small amount of 8-day ^{131}I as contaminant.

Sources of 30-minute ^{130}Cs were prepared by the (α, n) reaction on sodium iodide. Beryllium and aluminum absorbers were used to degrade the 42-MeV alpha beam of the Lewis Research Center cyclotron to about 14 MeV for these bombardments. After the bombardment, iodine was removed from the target material by precipitation as silver iodide. The cesium activity was then separated from the remaining solution by an extraction method (ref. 8). With this method, cesium (and rubidium) are selectively extracted from basic tartrate solutions with a solution of 4-sec-butyl-2(α-methylbenzyl) phenol in cyclohexane. The chemical treatment required approximately 15 minutes to complete. The only contaminant detected in the ^{130}Cs samples was identified as ^{129}Cs.

Equipment

The gamma-ray spectrometer consisted of a 20-cubic-centimeter lithium-drifted germanium detector, a low-noise pulse amplifier, and a 4096-channel pulse-height analyzer. This system had an energy resolution of approximately 6 keV for 1-MeV gamma rays.

Some 7.6- by 7.6-centimeter NaI(Tl) scintillation detectors were also used for gamma-gamma coincidence measurements. These could be used together or with the Ge(Li) detector as suited the experiment. The 4096 channel analyzer had two analog-to-digital converters and could be used in a two-dimensional mode to record simultaneously all coincidences from two scintillation detectors.

Three scintillation detectors were used simultaneously in an angular correlation measurement of ^{130}I. Their arrangement is shown in figure 1. One of the detectors (the gating detector) was connected to a single channel analyzer set to straddle a particular

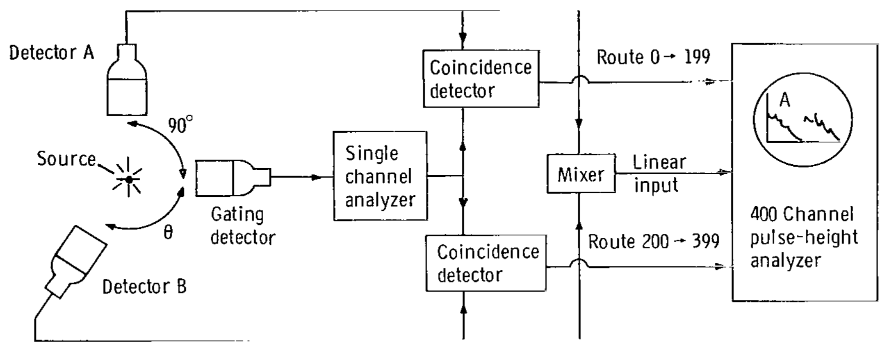


Figure 1. - Arrangement of scintillation detectors used in angular correlation measurements.

photopeak from that detector. The other two detectors were positioned so that detector A was a 90° relative to the source and the gating detector, but angle θ between detector B and the gating detector could be varied. The source and all three detectors were coplanar. Pulses from either A or B, coincident with pulses in the acceptance window of the gating detector were recorded in separate halves of the memory of a 400-channel pulse-height analyzer by means of routing pulses from the associated coincidence detectors. The angular correlation could then be obtained by normalizing the intensity of a photopeak in the detector at θ to the intensity of the corresponding peak in the detector at 90°.

Data Analysis

The spectra obtained using the Ge(Li) detector were analyzed by the method of least squares to fit peaks, Compton edges, and a background continuum to the data. From these fits were obtained the values of peak location and intensity and their statistical uncertainties.

The energies of gamma-ray peaks were determined by means of a calibration equation; a third order polynomial in peak location was used. The coefficients of the calibration equation were determined for each spectrum by using some of the strongest peaks as internal energy standards. These internal standards were determined, in turn, from mixed spectra in which the ^{130}Cs and ^{130}I gamma spectra were deliberately contaminated with gamma rays of well known standards. (See ref. 9 for an extensive compilation of gamma-ray energy standards.) The energy standards used in the present investigation were gamma rays of bismuth-207, cobalt-56, cobalt-60, sodium-22, yttrium-88, ^{137}Cs, ^{131}I, and annihilation radiation. Uncertainties given for the gamma-ray energy results include allowance for uncertainties in the energies of the calibration photopeaks and for uncertainties in the locations of both the calibration photopeaks and the unknown photopeaks.

Relative gamma-ray intensities were obtained from the pulse-height spectrum peak intensities by use of an empirical relative photopeak efficiency curve (ref. 10). The errors given for the gamma-ray intensities allow for ±10 percent uncertainty in the relative photoefficiency values read from this curve, as well as for statistical uncertainty in the areas of the photopeaks in the spectra.

The angular correlation function $W(\theta)$ was measured as the ratio

$$W(\theta) = \frac{\text{Photopeak counts in detector B}}{\text{Photopeak counts in detector A}}$$

for several values of θ (fig. 1). These were then used in a least-squares calculation to obtain the best-fit coefficients and their uncertainties in the equation

$$W(\theta) \cong A_0 + A_2P_2 (\cos \theta) + A_4P_4 (\cos \theta) \qquad (1)$$

where P_2 and P_4 are the even Legendre polynomials. Finally, these coefficients were corrected for finite geometry effects (ref. 11) and normalized to $A_0 = 1$.

Source half-life was determined from the peak intensities of successive Ge(Li) detector spectra. With the source position fixed, spectra were recorded for several intervals of equal duration. The half-life was then determined by a least-squares analysis of the time dependence of the gamma-ray peak intensities. In this analysis, the time duration of each spectrum was taken to be that measured by the "live time" clock of the pulse-height analyzer. The mean time of each interval, determined by an ordinary clock, was used to represent the time at which the corresponding spectrum was taken. Uncertainty reported for the half-life is that caused by statistical uncertainties in the peak intensities and in the spectrometer live time.

RESULTS AND LEVEL SCHEME FOR DECAY OF ^{130}I

Gamma-Ray Spectrum

Figure 2 shows the low-energy gamma rays emitted by ^{130}I. The peak at 510.9 keV is believed to be a nuclear gamma ray from ^{130}I, rather than annihilation radiation. This peak has the proper half life for ^{130}I, but there is not enough energy available for ^{130}I to decay to ^{130}Te by positron emission (ref. 12). Figure 3 shows the high energy gamma rays emitted by ^{130}I. The upper spectrum (fig. 3(a)) is that of a source 13 centi-

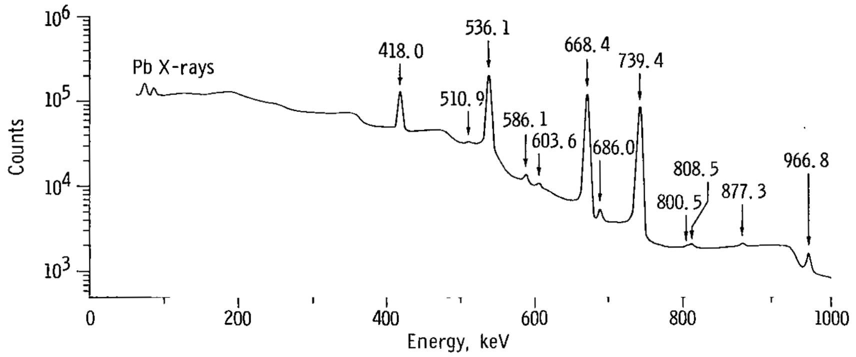


Figure 2. - Spectrum of low-energy gamma rays emitted by iodine 130; observed by Ge(Li) detector.

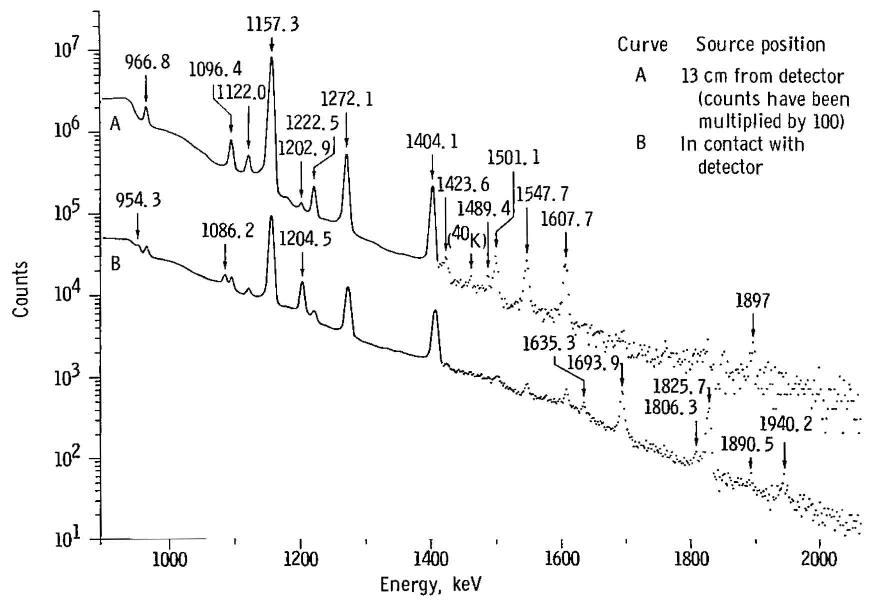


Figure 3. - Spectra of high-energy gamma rays emitted by iodine-130; observed by Ge(Li) detector. (Individual data points are replaced by a smooth line in part of the spectrum.)

meters from the detector; counts have been multiplied by 100 for clarity in reading the figure. The lower spectrum is that of the same source placed in contact with the detector container. Sum peaks, visible in curve B and not in curve A are marked. The 1272, 1404, and 1501 keV peaks also appear to be distorted in curve B by the presence of sum peaks near the photopeak energies. The relative intensities of gamma rays from ^{130}I are listed with the gamma-ray energies in table I. Interpretation of the sum peaks is given in table II.

Coincidences between gamma rays emitted by ^{130}I were studied using a 27-cubic-centimeter Ge(Li) detector gated by a 7.6- by 7.6-centimeter NaI(Tl) detector. However, only the previously known coincidences among the five strongest gamma rays were observed.

^{130}Xe Level Scheme Excited in Decay of ^{130}I

Several groups have previously studied the decay of ^{130}I (refs. 4, 12, 13). In the most recent (ref. 4), a beta-ray spectrometer and gamma-ray scintillation counters were used to detect the radiations from ^{130}I; the following excited states of ^{130}Xe were deduced: 2^+ at 540 keV, 4^+ at 1210 keV, 5^+ at 1950 keV, and 6^+ at 2370 keV. The results of the present investigation are consistent with these earlier results.

The level scheme of ^{130}Xe deduced from the decay of ^{130}I is shown in figure 4(a). The sum peaks observed in figure 3 (curve B) indicate coincidences between the 668.4-keV gamma ray and the 966.8- and 1222.5-keV gamma rays; this is the only evidence for levels at 2171.3 and 2427.0 keV. Levels of ^{130}Xe are deduced at 536.1±0.1, 1122.1±0.1, 1204.5±0.1, 1808.1±0.1, 1943.9±0.2, 2171.3±0.2, 2361.8±0.2, 2427.0±0.2, 2608.6±0.2, and 2752.3±0.2 keV. Eight of the 24 transitions observed in the decay of ^{130}I (table I) have not been placed in the level scheme in figure 4(a). Consideration of the gamma-ray energies would allow placement of additional levels of ^{130}Xe at 1632.5 and 2143.8 keV. These hypothesized levels would apparently be populated directly in the decay of 5^- ^{130}I, but no transition from either level to the 4^+ level at 1204.5 keV has been observed. Since it is then very hard to understand what the nature of these hypothesized levels could be, they have not been included in figure 4(a).

The transition intensities shown in figure 4(a) are given in percent of decays of ^{130}I. The log ft values and relative intensities of the transitions from ^{130}I were calculated from the intensities of the gamma rays (table I) and the maximum energy (ref. 4) of 1.042 MeV for the beta-ray group populating the 1943.9-keV state of ^{130}Xe.

TABLE I. - ENERGIES AND RELATIVE INTENSITIES

OF GAMMA RAYS FROM ^{130}I

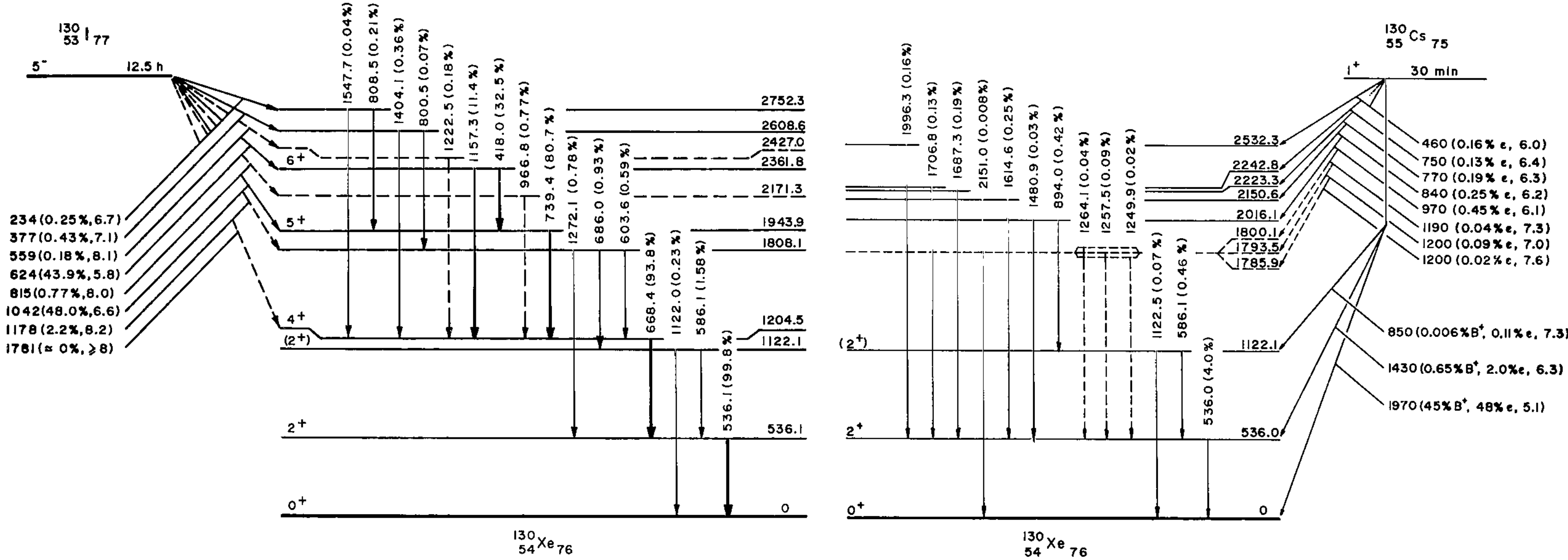
Energy, keV	Relative intensity	Energy, keV	Relative intensity
418.0±0.1	32.6±4.6	[a]1096.4±0.1	0.50±0.07
[a]510.9±0.2	0.62±0.09	1122.0±0.2	0.23±0.03
536.1±0.1	100	1157.3±0.1	11.4±1.6
586.1±0.1	1.58±0.23	[a]1202.9±0.5	0.02±0.006
603.6±0.1	0.59±0.09	1222.5±0.1	0.18±0.03
668.4±0.1	94.0±13	1272.1±0.1	0.78±0.11
686.0±0.1	0.93±0.13	1404.1±0.1	0.36±0.05
739.4±0.1	80.8±11	[a]1423.6±0.3	0.03±0.006
800.5±0.5	0.07±0.02	[a]1489.4±0.5	0.01±0.003
808.5±0.2	0.21±0.03	[a]1501.1±0.2	0.04±0.008
[a]877.3±0.2	0.18±0.03	1547.7±0.3	0.04±0.007
966.8±0.1	0.77±0.11	[a]1607.7±0.4	0.04±0.007

[a]Not fitted into level scheme of fig. 4.

TABLE II. - ANALYSIS OF SUM

PEAKS IN FIGURE 3(b)

Energy, keV	Component gamma rays, keV
954.3±0.2	418.0±0.1 + 536.1±0.1
1086.2±0.2	418.0±0.1 + 668.4±0.1
1204.5±0.1	536.1±0.1 + 668.4±0.1
≈1275	536.1±0.1 + 739.4±0.1
≈1408	668.4±0.1 + 739.4±0.1
≈1502	536.1±0.1 + 966.8±0.1
1635.3±0.6	668.4±0.1 + 966.8±0.1
1693.9±0.3	536.1±0.1 + 1157.3±0.1
1806.3±0.4	536.1±0.1 + 1272.1±0.1
1825.7±0.2	668.4±0.1 + 1157.3±0.1
1890.5±1.5	668.4±0.1 + 1222.5±0.1
1940.2±1.0	536.1±0.1 + 1404.1±0.1



(a) Populated in beta decay of iodine-130. (Spin assignments, except that of the 1122.1-keV state are from ref. 4.)

(b) Populated in beta decay of cesium-130.

Figure 4. - Energy levels of xenon-130. Energies are in keV. Gamma ray intensities, expressed in terms of percent decays of the parent isotope, are shown in parentheses.

Angular Correlation Measurement

The angular correlation between the 739.4- and 668.4-keV gamma rays in cascade was measured. Since these gamma rays are so much more intense than the newly discovered weak gamma rays, the angular correlation results should not be significantly affected by the presence of those weaker transitions. The values obtained for the coefficients in the correlation equation (eq. (1)), are $A_2 = 0.105 \pm 0.025$ and $A_4 = -0.022 \pm 0.037$ (normalized to $A_0 = 1.0$).

These results are consistent with the results of reference 13. Unfortunately, the angular-correlation results do not determine unambiguously the dipole-quadrupole mixing ratios for the transitions de-exciting the 1943.9- and 2361.8-keV levels, so the spins of these levels are not determined uniquely. The 1943.9- and 2361.8-keV levels have spins of either 5 or 6.

RESULTS AND LEVEL SCHEME FOR DECAY OF ^{130}Cs

Gamma-Ray Spectrum

Figure 5 shows a gamma-ray spectrum of ^{130}Cs obtained by adding Ge(Li) spectra of six sources made in successive bombardments. Double-escape peaks (which occur 1022

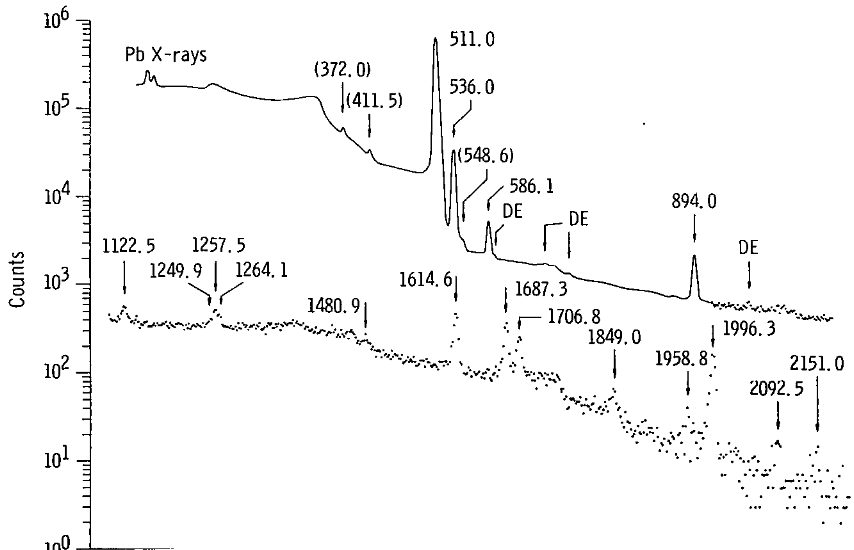


Figure 5. - Spectrum of gamma rays emitted by cesium 130; observed by Ge(Li) detector. Energies of gamma rays emitted by cesium 129 contaminant are given in parentheses. Energy scale graduation has been omitted and spectrum folded twice to reduce length. Individual data points are replaced by smooth line in part of spectrum. (DE indicates double escape peak.)

keV lower in energy than the corresponding photopeak) are labeled DE, and parentheses enclose the energies of three gamma rays from ^{129}Cs, the only contaminant observed. Relative intensities of all nuclear gamma rays from ^{130}Cs were determined from this combined spectrum. The relative intensity of the annihilation radiation was determined in a separate experiment in which the source was contained in an absorber thick enough to stop all the positrons. These relative intensities are given with the gamma-ray energies in table III.

The gamma rays of energy 511.0, 536.0, 586.1, 894.0, and 1996.3 keV were sufficiently intense that their half-lives could be obtained. The weighted average of these results was 29.9±0.1 minutes for the half-life of ^{130}Cs.

TABLE III. - ENERGIES AND RELATIVE INTENSITIES OF GAMMA RAYS FROM ^{130}Cs

Energy, keV	Relative intensity
[a]511.006±0.002	2290±320
536.0±0.1	100
586.1±0.1	11.6±1.7
894.0±0.1	10.5±1.5
1122.5±0.4	1.8±0.3
1249.9±1.5	0.5±0.2
1257.5±0.6	2.1±0.4
1264.1±0.9	1.1±0.3
1480.9±0.9	0.8±0.3
1614.6±0.3	6.1±0.9
1687.3±0.3	4.7±0.7
1706.8±0.3	3.3±0.5
[b]1849.0±0.7	0.67±0.14
[b]1958.8±1.0	0.34±0.09
1996.3±0.5	4.0±0.6
[b]2092.5±1.1	0.26±0.07
2151.0±1.3	0.20±0.06

[a]Annihilation radiation. Energy value adopted from ref. 9.
[b]Not fitted into level scheme of fig. 4.

Gamma-Gamma Coincidences

Coincidences between gamma rays emitted by ^{130}Cs were studied with two 7.6- by 7.6-centimeter NaI(Tl) detectors and the 4096-channel analyzer used in the two-dimensional mode (64 × 64 channels) so that all coincidence events could be recorded simultaneously. The detectors were arranged at 90° with respect to each other and the source with 5 centimeters of lead between detectors to suppress Compton-scattering coincidences.

Figures 6 and 7 show some of the coincidence results. The singles spectrum observed by one detector (without the coincidence requirement) is at the top of figure 6. Shown also are spectra seen by the same detector in coincidence with the channel corresponding to annihilation radiation (curve A), and in coincidence with channels centered at approximately 550 keV (curve B), and 600 keV (curve C). Counts in spectra A and B have been multiplied by 100 and 10, respectively, to make the plot more clear. The 511-, 536-, and 586-keV gamma rays are not clearly resolved in these spectra. Nevertheless,

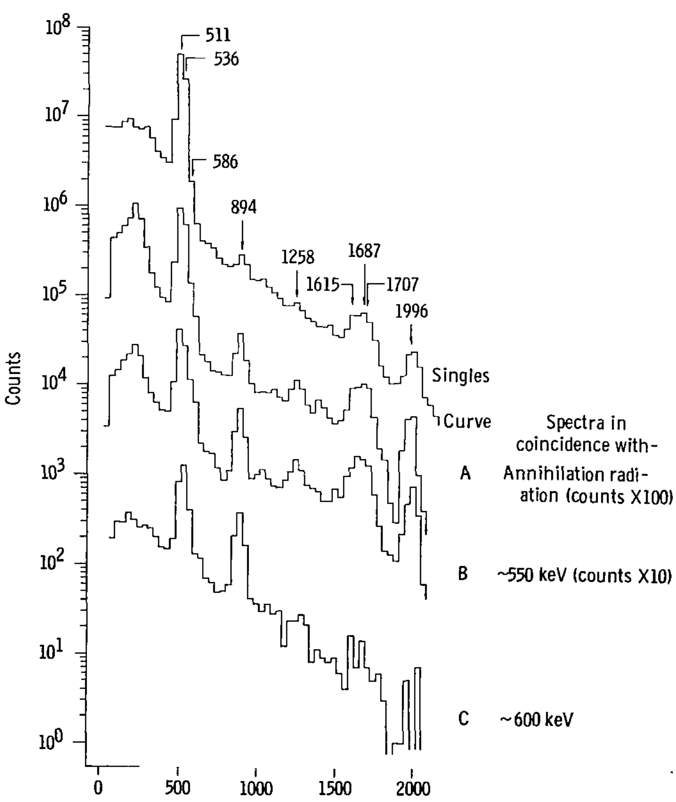


Figure 6. - Scintillation spectra of gamma rays emitted by cesium-130.

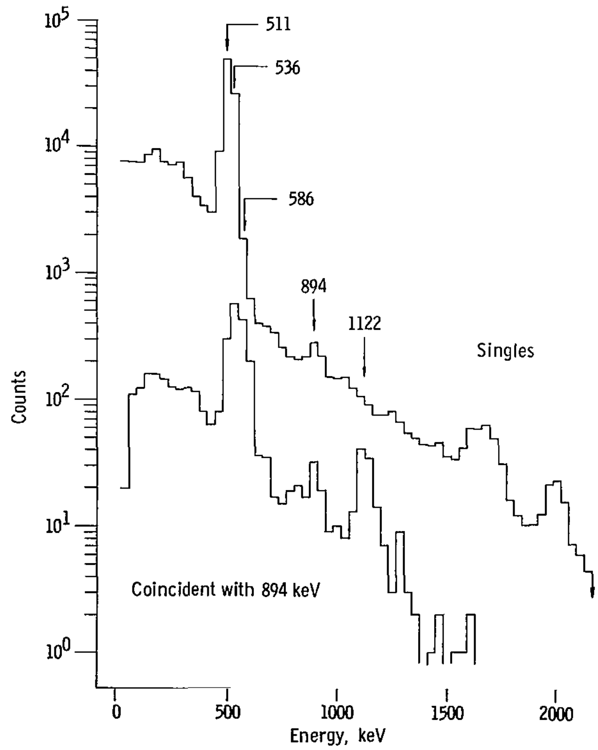


Figure 7. - Scintillation spectrum of gamma rays emitted by cesium-130 in coincidence with 894 keV compared with singles spectrum.

figure 6 offers good evidence that the 894-, 1615-, 1687-, 1707-, and 1996-keV gamma rays, and at least one of the three gamma rays with energy near 1260 keV, are coincident with the 536-keV gamma ray. Furthermore, of these gamma rays, only the 894-keV gamma ray is coincident with the 586-keV gamma ray. Figure 7 shows that the 1122-keV gamma ray is in coincidence with the 894-keV gamma ray; in the coincidence spectrum, the intensity of the 1122-keV peak is markedly enhanced over that in the singles spectrum.

^{130}Xe Level Scheme Excited in Decay of ^{130}Cs

The energy of the most energetic positrons emitted by ^{130}Cs was measured by Smith, Mitchell, and Caird (ref. 14) as 1.97 MeV. Several investigators (refs. 5 and 15 to 17) have studied gamma rays emitted in the decay of ^{130}Cs. A 535-keV, 2^+ excited state and a 1122-keV, 0^+ or 2^+ excited state have been deduced (ref. 5). The results of the present investigation are consistent with these earlier results.

The level scheme of ^{130}Xe deduced from the decay of ^{130}Cs is shown in figure 4(b). Excited states in ^{130}Xe have been deduced from the energy and intensity values of table III, from the coincidence data of figures 6 and 7, and from those cases in which the sum of the energies of two gamma rays coincides with the energy of a third. These states are 536.0±0.1, 1122.1±0.2, 1785.9±1.5, 1793.5±0.6, 1800.1±0.9, 2016.1±0.2, 2150.6±0.3, 2223.3±0.3, 2242.8±0.3, and 2532.3±0.5 keV. All but three of the gamma rays in table III have been placed in the level scheme of figure 4(b).

The transition intensities shown in figure 4(b) are given as percents of all decays of ^{130}Cs; the 1.6-percent beta decay to ^{130}Ba (ref. 14) has been included. The log $\underline{ft}$ values and relative intensities of the transitions from ^{130}Cs were calculated from the intensities of the gamma rays (table III) and the maximum positron energy of 1.97 MeV (ref. 14). For each of the levels populated by positron emission, the intensity ratio of K-electron capture to positron emission was assumed to be the value obtained theoretically (ref. 18) for allowed beta decay. Capture of electrons from higher shells was assumed to be 10 percent of that from the K shell.

DISCUSSION OF RESULTS

The results of the present study of the beta-decay of ^{130}I and ^{130}Cs to ^{130}Xe are summarized in the level schemes of figure 4.

Only two levels of ^{130}Xe have been found at approximately twice the energy of the 2^+ first excited state. The character of the 1204.5-keV state was determined to be 4^+ (refs. 4 and 13). Gföller and Flammersfeld (ref. 5) ascribed a character of 0^+ or 2^+ to the 1122.1 keV-state because it is populated in the decay of 1^+ ^{130}Cs. They did not observe a transition from this level to the ground state of ^{130}Xe, but such a transition has been observed in the present study. It is thus possible to discard the 0^+ alternative. A (2^+) character is assumed for the 1122.1-keV state on the basis of the systematics of the even Xe isotopes (fig. 8).

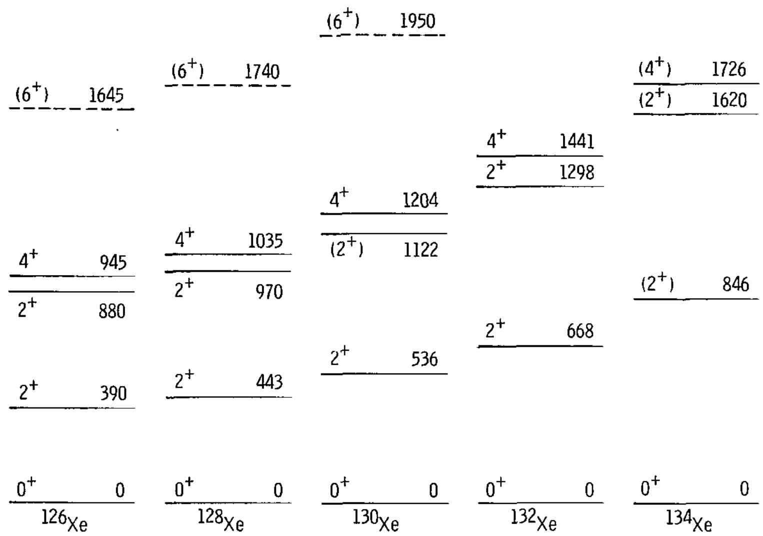


Figure 8. - Excited states of even xenon isotopes. (Data are taken from refs. 7 and 19 to 23, and this work.)

The gamma-ray branching ratio for the de-excitation of the 1122.1-keV state (denoted $(2^+)'$) has been determined to be $I[(2^+)' \rightarrow 0^+]/I[(2^+)' \rightarrow 2^+] = 0.15 \pm 0.03$. If one neglects internal conversion and assumes that both transitions are pure electric quadrupole, the ratio of the reduced transition probabilities for the two modes of de-excitation of the 1122.1-keV state is

$$\frac{B[E2;\ (2^+)' \rightarrow 0^+]}{B[E2;\ (2^+)' \rightarrow 2^+]} = \left[\frac{I(1122.1\ \text{keV})}{I(586.1\ \text{keV})}\right]\left(\frac{586.1}{1122.1}\right)^5 = 0.0058 \pm 0.0012$$

The analogous ratios, computed from the data of references 19 to 23, are 0.020 for ^{134}Xe, 0.0015 for ^{132}Xe, and 0.012 for ^{128}Xe.

No evidence was found for the existence of a possible 0^+ level of ^{130}Xe at about twice the energy of the first excited state. In particular, no gamma ray was observed that could be interpreted as a transition from such a 0^+ level to the 536.1-keV level, and no gamma rays were observed to populate such a 0^+ level in the de-excitation of higher levels of ^{130}Xe. If there were a 0^+ level of ^{130}Xe degenerate with the (2^+) level at 1122.1 keV, the 0^+ level should be populated in the decay of 1^+ ^{130}Cs but not in the decay of 5^- ^{130}I. Then the presence of the $0^+ \rightarrow 2^+$ transition would make the branching ratio I(1122.1 keV)/I(586.1 keV) appear smaller when the parent isotope is ^{130}Cs than when the parent isotope is ^{130}I. However, in this study, the same detector was used to study the decay of both ^{130}I and ^{130}Cs, and no difference in the branching ratio was observed. Hence, it appears that, if there is a 0^+ state of ^{130}Xe at about twice the energy of the first excited state, it is populated at most very weakly in the decay of ^{130}Cs. Note that the preceding discussion has not considered the possibility that such a 0^+ level is populated but is de-excited solely by E0 conversion electrons to the ground state. There also remains the possibility that the 0^+ "vibrational triplet state" of ^{130}Xe exists but, because of the nature of the nuclear potential, does not lie low enough in energy that it could be recognized as such (refs. 24 and 25).

If the 1808.1 keV level of ^{130}Xe is populated directly in the decay of 5^- ^{130}I, the most likely spin for this level is 4. That transitions lead from this level to both 2^+ and 4^+ levels suggests that this level does not have very high spin, while any spin less than 4 would require that the beta transition populating this level be at least unique first forbidden.

Morinaga and coworkers (refs. 6 and 7) have reported exciting a level of ^{130}Xe at about 1950 keV during reaction studies. Although they did not directly measure the spin of this level, they assumed it to be 6^+. If normal selection rules apply, a 6^+ level of ^{130}Xe could be populated in the decay of 5^- ^{130}I. However, Daniel et al. (ref. 4) assigned a character of 5^+ to a level of ^{130}Xe at about 1950 keV populated in the decay of ^{130}I. It is possible that this is the same level, for in the present study of the decay of ^{130}I, no evidence was found for the existence of an additional level of ^{130}Xe close to that whose energy is measured as 1943.9 keV.

Bergstrom et al. (ref. 26) have performed an experiment in which excited states of ^{130}Xe are populated in the (α, Xn) reaction on separated tellurium isotopes and the angular distribution of the de-excitation gamma rays is measured with respect to the alpha beam direction. These workers report populating a 6^+ level at 1945 keV and a 5^- level at 2060 keV. With normal selection rules, population of a 5^- level of ^{130}Xe in the decay of 5^- ^{130}I would be allowed, but no evidence was found for such a level in the present study. It must be stressed that unusual selection rules may apply, so that excited states of ^{130}Xe populated in the reaction studies may not be populated in beta decay.

CONCLUDING REMARKS

An experimental study has been made of the beta decay of ^{130}I and of ^{130}Cs to ^{130}Xe. Twenty-four gamma rays were identified in the decay of ^{130}I and 16 gamma rays in the decay of ^{130}Cs. Eighteen excited energy levels have been deduced in the daughter nucleus ^{130}Xe. No evidence has been found for the population of a possible 0^+ vibrational triplet member at about twice the energy of the first excited state.

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National Aeronautics and Space Administration,
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