Decays of ^{126}Ba and ^{126}Cs

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The neutron deficient ^{126}Ba has been produced by the reactions ^{115}In(^{16}O, 5n)^{126}La $\xrightarrow{\beta^+, EC}$ ^{126}Ba, ^{121}Sb(^{11}B, 6n)^{126}Ba, and ^{133}Cs(p, 8n)^{126}Ba. Its decay properties have been studied in equilibrium with the daughter activity of ^{126}Cs. About 100 γ rays have been observed to be associated with the decay of the ^{126}Ba-^{126}Cs mass chain. The assignment of γ rays to ^{126}Ba and ^{126}Cs activities has been done by measuring γ-ray spectra gated by K x rays of Cs and Xe, respectively. The γ-γ and β-γ coincidence studies have been performed by using large volume Ge(Li) and plastic detectors and a two parameter analyzer system. Conversion coefficients of intense γ transitions have been measured by using a conversion electron spectrometer consisting of a Ge(Li) detector and a cooled Si(Li) detector. Decay schemes of ^{126}Cs and ^{126}Ba are proposed. The levels in ^{126}Xe are compared with predictions of the collective model.

[RADIOACTIVITY ^{126}Ba, ^{126}Cs [from ^{115}In(^{16}O, 5n), ^{121}Sb(^{11}B, 6n), and ^{133}Cs(p, 8n)]; measured E_γ, I_γ, I_{ce}, β-γ, x-γ, γ-γ coincidence; deduced levels, J, π, logft, CC, multipolarities; Ge(Li), Si(Li), plastic detectors; natural targets.]

I. INTRODUCTION

Since the prediction of the possible existence of a new region of deformation[1] among the neutron deficient nuclei with $50 < N, Z < 80$, there have been numerous theoretical[2-7] and experimental[8-13] studies to elucidate the nature of the excited states of the nuclei in the mass region around $A = 126$. In most of the above studies it was indicated that oblate deformations may be preferred in nuclei with mass numbers in the vicinity of 126, or that the excited states belonging to both prolate and oblate deformations may coexist. In more recent calculations it has been shown[7,14] that the prolate deformations are more stable compared to oblate ones and therefore, a prolate ground state should be preferred. However, the difference between the energies of the prolate and oblate minima comes out to be small and hence, shape isomerism may exist in some nuclei. On the other hand, the generalized collective model of Gneuss and Greiner[15] has been applied to the study of these nuclei by Habs *et al.*[5] The energies and γ-decay characteristics of various levels have been predicted. More experimental data would be needed to understand the extent of the validity of various models.

Experimental data on the decay of the ^{126}Ba – ^{126}Cs mass chain are very scanty. Kalkstein and Hollander[16] discovered ^{126}Ba in the ^{115}In(^{14}N, xn) reaction and assigned the mass using a time-of-flight mass spectrometer. They observed a β^+ group of 3.8 MeV end-point energy and γ rays of 388 and 880 keV. Preiss and Strudler[17] produced ^{126}Ba in (HI, xn) reactions and reported a half-life 103 ± 5 min. D'Auria[18] used a small Ge(Li) detector in the study of the ^{126}Ba and ^{126}Cs activities and reported four γ transitions. Recently, Blinowska *et al.*[19] and Arl't *et al.*[20] have studied γ spectra from the decay of ^{126}Ba using large Ge(Li) detectors and suggested decay schemes based on sums and differences of γ-ray energies[19] and preliminary coincidence data.[20]

The present study was undertaken with the aim of obtaining further knowledge on the decay of the ^{126}Ba-^{126}Cs mass chain and establishing their decay schemes. Preliminary results of this work have been reported earlier.[21,22]

II. SOURCE PREPARATION

For the study of singles γ-ray spectra, radioactive sources of ^{126}Ba were obtained by the ^{115}In(^{16}O, 5n) and ^{121}Sb(^{11}B, 6n) reactions. Metallic indium and antimony of 99.999% purity were used as target materials. The targets were prepared by vacuum evaporation of the source material on 0.0025 cm thick Al foils. The typical thickness of the target was 2 mg/cm^2. The irradiations were done at the Heavy Ion Accelerator Laboratory, Yale University. Recoiling product nuclei were collected on thin aluminum catcher foils. After the irradiation the catcher foil was removed from the target assembly and dissolved in hot dilute hydrochloric acid. Barium was radiochemically separated using the procedure given by Li *et al.*[23]

The sources used in the γ-γ and β-γ coincidence studies and conversion electron measurements were obtained from the $^{133}Cs(p,8n)$ reaction. Compressed pills of $CsNO_3$ weighing 100 mg and having a diameter of 0.5 cm were bombarded by 100 MeV protons in the external beam of the McGill synchrocyclotron. The irradiated pills were allowed to cool for one hour to let the ^{127}Ba activity ($T_{1/2}$ = 13 min) decay. Barium was then separated by using the following procedure. The irradiated pills were dissolved in distilled water. A drop of $Ba(NO_3)_2$ solution was added as carrier. The Ba activity was precipated as $Ba(OH)_2$ by adding a solution of NH_4OH. The precipitate was washed and centrifuged several times to remove the Cs activity. Thin sources were prepared by making a homogeneous emulsion of the precipitate with water and then depositing it on Al foils.

III. APPARATUS AND RESULTS

A. Singles γ-ray measurements

We used Ge(Li) detectors having 7.8% and 18% efficiencies and overall resolutions 2.0 and 2.3 keV, respectively, for the 1333 keV γ ray of ^{60}Co. Low-energy photon spectra were studied using thin window intrinsic Ge and Ge(Li) detectors; the resolution was 450 eV for the 81 keV γ ray of ^{133}Ba. The spectra were recorded with data handling systems based on PDP8 and PDP15 computers. The energies and relative intensities of the γ rays were determined using program SAMPO.[24]

A typical γ-ray spectrum of the ^{126}Ba-^{126}Cs mass chain is shown in Fig. 1. The energies and relative intensities are listed in Table I. The assignment of γ transitions to ^{126}Ba and ^{126}Cs was done by looking at the γ rays in coincidence with the Cs and Xe x rays. The half-life of ^{126}Ba was precisely measured by following the decay of the photopeak intensities of well-known intense γ rays of 388.6, 233.6 and 257.6 keV. An elaborate dead-time correction procedure[25] was adopted. The half-life of ^{126}Ba was found to be 100 ± 2 min. The assignment of weaker γ rays to ^{126}Ba and ^{126}Cs was done by measuring their half-lives, and the ratio of their photopeak intensities with that of

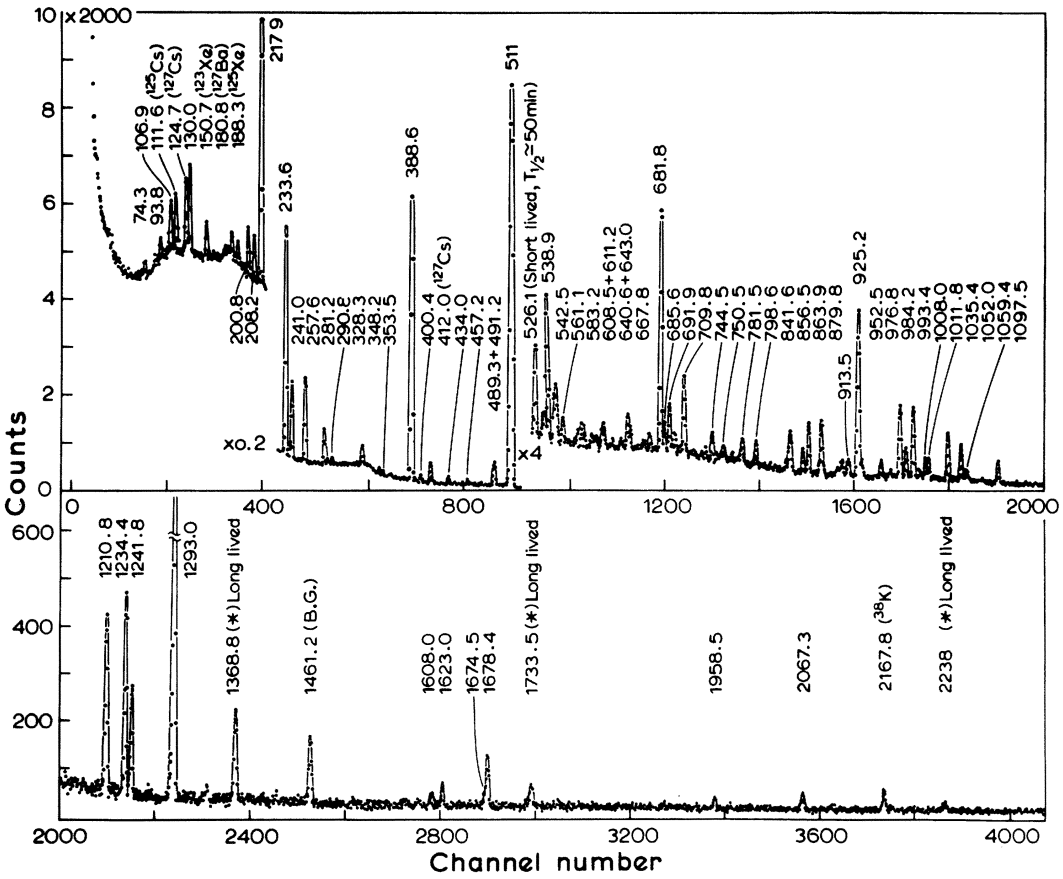

FIG. 1. γ-ray spectrum of the ^{126}Ba-^{126}Cs mass chain as measured with a 50 cm^3 Ge(Li) detector. Radioactive sources produced by the $^{115}In(^{16}O,5n)^{126}La \xrightarrow{\beta^+,EC} {}^{126}Ba$ reaction were used in this measurement. γ rays indicated with an asterisk (*) could not be assigned to any of the known Ba isotopes or their daughter activities.

TABLE I. Energies and relative intensities of γ rays observed in the decay of ^{126}Ba and its daughter ^{126}Cs. The γ rays assigned to the decay of ^{126}Ba are identified as Ba, and those assigned to the daughter activity of ^{126}Cs are labeled as Cs. The γ rays marked with an asterisk (*) are not included in the decay scheme.

Present work			Blinowska *et al.*			Arl't *et al.*	
E_γ	I_γ	Identification	E_γ	I_γ	Identification	E_γ	I_γ
						85.9	0.4
94.5±0.3	0.6 ±0.2	Ba	94.1±0.3	0.6±0.2	^{126}Ba	93.2	0.5
			103.8±0.3	0.7±0.2	A=126	102.9	0.4
106.9±0.2	1.2 ±0.3	Ba	107.3±0.3	1.5±0.2	^{126}Cs	106.7	0.9
126.5±0.2*	1.1 ±0.3	Ba	127.0±0.3	1.3±0.3	A=126	126.2	0.9
130.0±0.2	1.9 ±0.4	Ba	130.0±0.3	2.4±0.3	A=126	129.4	1.7
			171.7±0.3	<1	A=126	149.6	0.7
192.5±0.5	Weak	Ba	180.7±0.4	<1	A=126		
201.1±0.2	1.5 ±0.4	Ba	201.3±0.3	1.3±0.5	A=126	200.7	1.3
203.8±0.3	0.82±0.20	Ba				203.1	0.5
208.2±0.2	1.3 ±0.3	Ba				208.0	1.1
213.5±0.3*	0.43±0.20	A=126					
217.9±0.1	10.0 ±1.0	Ba	218.2±0.3	10.0±1.4	^{126}Ba	217.7	8.6
231.7±0.3	2.2 ±0.3						
233.6±0.1	48.2 ±2.5	Ba	233.6±0.3	50±5	^{126}Ba	233.4	44.6
239.3±0.5	1.1 ±0.3	Ba					
241.0±0.1	14.7 ±1.2	Ba	241.0±0.3	14.5±1.8	^{126}Ba	240.7	13.3
257.6±0.1	18.7 ±1.0	Ba	257.5±0.3	17.9±1.2	^{126}Ba	257.3	17.4
269.3±0.3*	0.44±0.20	Ba					
281.2±0.2	7.5 ±0.8	Ba	281.2±0.3	7.2±0.6	^{126}Ba	281.0	7.4
284.9±0.3	1.0 ±0.3	Ba	285.1±0.3	1.0±0.3	A=126	284.8	0.9
						290.6	1.4
290.8±0.3	1.3 ±0.3	Ba	290.9±0.3	1.4±0.3	A=126		
303.4±0.5	0.3 ±0.1	Ba					
308.9±0.3	0.8 ±0.2	Ba	309.0±0.6	0.7±0.4	A=126		
320.5±0.5	0.2 ±0.1	Ba					
324.8±0.5	0.6 ±0.2	Ba					
328.3±0.2	5.1 ±0.5	Ba	328.3±0.3	6.1±0.7	^{126}Ba	328.2	4.8
348.5±0.2	1.8 ±0.4	Ba				348.3	1.7
353.5±0.3	1.3 ±0.3	Ba				353.0	1.4
						361.7	1.0
364.6±0.3	1.1 ±0.3	Cs	365.1±0.6	1.1±0.5	A=126	364.2	0.8
			382.4±0.7	1.6±0.6	A=126		
			385.7±0.3	5.1±0.9	A=126		
388.6±0.1	100	Cs	388.7±0.3	100	^{126}Cs	388.5	100
392.5±0.2	1.9 ±0.4	Ba				392.2	1.1
400.6±0.2	2.8 ±0.4	Ba	400.5±0.3	2.4±0.5	A=126	400.4	2.3
415.5±0.3	1.5 ±0.3	Ba	415.1±0.3	1.6±0.5	A=126	414.7	1.5
434.0±0.2	2.8 ±0.4	Cs	434.1±0.3	2.6±0.5	A=126	433.9	2.2
441.0±0.5	1.0 ±0.2	Ba	441.8±0.4	1.1±0.3	A=126		
452.8±0.3	0.45±0.20	Ba					
457.2±0.2	1.7 ±0.3	Ba	457.3±0.3	2.1±0.5	A=126	457.2	1.4
475.5±0.3	0.8 ±0.2	Ba				474.6	1.1
489.3±0.2	7.1 ±0.7	Ba				490.7	17.7
491.2±0.2	12.6 ±1.2	Cs	490.8±0.3	12 ±2	^{126}Cs		
						525.7	0.5
535.4±0.3	0.9 ±0.2	Ba				535.6	0.6
538.9±0.2	4.8 ±0.5	Ba	539.0±0.3	4.4±0.8	^{126}Cs	538.7	3.9
542.5±0.2	2.2 ±0.4	Ba	542.9±0.5	1.8±0.6	A=126	542.5	1.7
548.7±0.3	1.6 ±0.3	Cs				548.8	1.3
551.2±0.3	1.8 ±0.3	Ba				551.3	1.6
553.4±0.5	0.7 ±0.2	Cs				553.6	0.9
558.5±0.5	0.3 ±0.1	Ba					
561.1±0.5	0.7 ±0.3	Ba	561.2±0.5	1.0±0.4	^{126}Ba	560.4	0.8
						578.6	0.5
583.5±0.3	1.0 ±0.3	Ba	583.9±0.9	0.9±0.5	A=126		

TABLE I. *(Continued)*

Present work			Blinowska *et al.*			Arl't *et al.*	
E_γ	I_γ	Identification	E_γ	I_γ	Identification	E_γ	I_γ
608.5±0.5	1.0 ±0.2	Ba	610.3±0.5	1.8±0.6	^{126}Ba	608.6	1.0
611.2±0.5	1.2 ±0.2	Ba				610.9	1.2
602.3±0.5							
640.6±0.3	1.4 ±0.2	Ba	641.4±0.4	2.5±0.6	^{126}Ba	640.6	1.1
643.1±0.5	0.9 ±0.2	Ba				642.8	0.7
667.8±0.3	0.7 ±0.3	Ba				667.9	0.7
681.8±0.2	10.8 ±1.1	Ba	682.1±0.3	10.7±1.0	^{126}Ba	681.5	10.5
685.6±0.3	1.1 ±0.2	Ba				685.6	1.1
691.6±0.2	2.0 ±0.2	Ba	692.3±0.5	1.7±0.4	^{126}Ba	691.7	2.2
698.6±0.3	0.7 ±0.2	Ba				698.6	0.8
702.6±0.5	0.2 ±0.1	Ba					
709.8±0.3	3.7 ±0.8	Ba	710.4±0.3	3.6±0.6	^{126}Cs	709.8	3.0
713.1±0.5	0.2 ±0.1	Cs					
736.5±0.3	0.6 ±0.2						
744.5±0.3	1.4 ±0.2	Ba				744.3	0.9
750.5±0.5	0.3 ±0.1	Ba					
779.0±0.5*	0.4 ±0.2	Ba				779.2	0.5
781.5±0.3	1.1 ±0.2	Ba	782.8±0.5	1.7±0.6	^{126}Ba	781.6	1.0
798.6±0.3	1.3 ±0.2	Cs				798.5	1.0
835.9±0.5	0.4 ±0.2	Ba					
839.5±0.5	1.2 ±0.3	Ba					
841.6±0.5	2.6 ±0.5	Ba	841.9±0.5	3.8±0.8	^{126}Ba	841.0	3.6
856.5±0.3	1.8 ±0.3	Ba				856.3	1.4
863.9±0.2	3.6 ±0.7	Ba	864.3±0.4	3.1±0.5	^{126}Ba	863.8	2.9
876.8±0.5	0.7 ±0.2	Ba					
879.8±0.3	3.7 ±0.7	Cs	880.4±0.5	3.5±0.6	^{126}Cs	879.6	3.8
882.5±0.5	0.7 ±0.2	Ba					
899.2±0.5	0.5 ±0.2	Ba					
903.5±0.5	0.6 ±0.2	Ba				903.1	0.9
905.9±0.5	0.9 ±0.2	Ba				906.0	1.0
910.0±0.5	0.3 ±0.1	Ba				911.7	1.6
913.5±0.5	1.1 ±0.2	Ba					
925.2±0.2	11.8 ±1.2	Cs	926.0±0.6	12.8±1.5	^{126}Cs	925.1	11.7
929.6±0.5	1.5 ±0.3	Ba				928.9	1.2
						934.3	0.2
953.1±0.3	1.2 ±0.3	Ba				952.7	0.9
964.4±0.5	0.5 ±0.2	Ba				964.4	0.3
976.8±0.2	4.4 ±0.4	Ba	977.5±0.5	5.2±0.7	^{126}Ba	976.6	5.5
977.2±0.2		Ba					
984.2±0.3	2.8 ±0.6	Ba	984.4±0.5	2.1±0.4	A =126	983.5	2.3
993.4±0.3	6.0 ±1.0	Ba	993.8±0.5	5.4±0.7	^{126}Ba	992.9	5.4
1000.8±0.5	0.6 ±0.2	Ba				1000.4	0.5
1008.0±0.5	1.2 ±0.2	Ba					
1011.8±0.5	1.8 ±0.4	Ba				1011.4	1.6
1033.4±0.5	0.7 ±0.2	Cs	1033.7±0.8	0.9±0.6	A =126		
1035.4±0.3	4.0 ±0.8	Ba	1035.9±0.5	3.5±0.7	^{126}Ba	1035.2	3.4
1052.0±0.2	3.0 ±0.5	Ba	1052.6±0.6	2.8±0.6	^{126}Ba	1051.8	2.6
1059.4±0.5	1.0 ±0.2	Ba	1059.4±0.9	<1	A =126	1059.4	0.7
1097.5±0.5	1.7 ±0.4	Ba	1098.6±0.5	1.8±0.5	A =126	1097.5	1.9
1210.8±0.3	4.5 ±0.9	Ba	1211.0±0.6	3.9±0.8	^{126}Ba	1210.2	4.1
1234.4±0.3	4.8 ±0.9	Ba	1234.7±0.6	4.7±0.7	^{126}Ba	1234.1	4.7
1241.8±0.3	2.6 ±0.5	Ba	1242.9±0.6	2.7±0.5	^{126}Ba	1241.2	2.4
1289.8±0.5	0.9 ±0.2	Cs				1290.1	0.9
1293.0±0.3	9.1 ±1.0	Ba	1293.3±0.7	9.6±1.5	^{126}Ba	1293.1	9.0
1467.3±0.5	0.2 ±0.1	Cs					
1608.0±0.5	0.3 ±0.1	Cs					
1623.0±0.5	0.6 ±0.1	Cs				1622	0.8
1674.5±0.5	0.5 ±0.2	Cs				1673	0.3

TABLE I. *(Continued)*

Present work E_γ	Present work I_γ	Identification	Blinowska *et al.* E_γ	Blinowska *et al.* I_γ	Identification	Arl't *et al.* E_γ	Arl't *et al.* I_γ
1678.6±0.5	1.6 ±0.3	Cs	1678.2±0.5	1.8±0.6	A=126	1676	1.9
			1734.7±1.0	1.4±0.6	^{126}Cs		
1958.5±0.5	0.4 ±0.1	Cs					
2067.3±0.5	0.7 ±0.2	Cs	2064.6±1.6	0.8±0.4	^{126}Cs	2061	0.8
2155 ±1	0.06±0.02	Cs					
2178 ±1	0.22±0.04	Cs					
2408 ±1	0.27±0.05	Cs					
2456 ±1	0.16±0.03	Cs					
2503 ±1	0.09±0.03	Cs					
2567 ±1	0.08±0.03	Cs					

known peaks at various time intervals. A study of the photon spectra using thin window small intrinsic Ge and Ge(Li) detectors gave precise energies and relative intensities of the low-energy γ rays and also resolved some of the complex photopeaks (e.g., 231.7 and 233.6, 239.3 and 241.0 keV peaks). Figure 2 shows relevant portions of the low-energy regions of the γ spectrum of ^{126}Ba.

B. Conversion electrons

Conversion electron spectra were obtained using a 200 mm^2 × 3 mm cooled Si(Li) detector. The energy resolution [full width at half maximum (FWHM)] of the spectrometer was 2.7 keV for the 624 keV conversion line of ^{137}Cs. The γ-ray spectra were simultaneously accumulated using an 8% Ge(Li) detector. The conversion coefficients were normalized using the theoretical[26] conversion coefficients of the pure $E2$ 388.6 keV transition in ^{126}Xe. Figure 3 shows a typical conversion electron spectrum. The radioactive source used in this measurement was produced by the ^{133}Cs(p,8n)^{126}Ba reaction and therefore, appreciable amounts of interfering activities from other Ba and Cs nuclei were also present; for that reason, the conversion coefficients of only the intense γ transitions could be determined. The results of the analysis of the conversion electron spectra are listed in Table II.

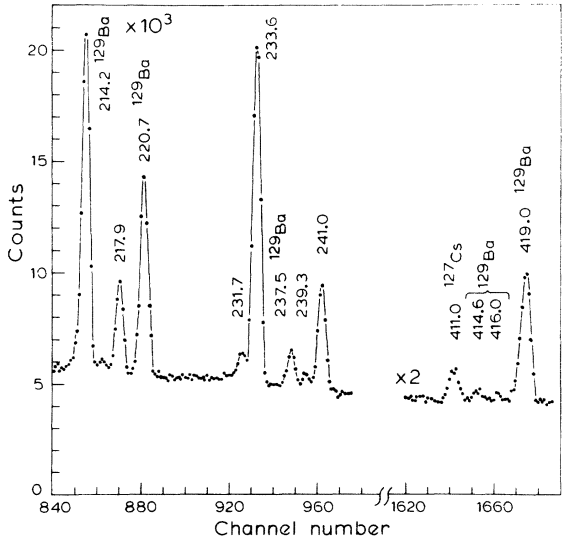

FIG. 2. A γ-ray spectrum of Ba activities produced in the ^{133}Cs(p,xn) reaction with a 100 MeV proton beam. The data were obtained by using a thin-window small Ge(Li) spectrometer.

C. Prompt γ-γ coincidences

The large volume Ge(Li) detectors (8% and 18%) were used in γ-γ time coincidence measurements. The detectors were placed at an angle of 180° with respect to each other. The scattering of photons from one detector to the other was suppressed by using a heavy metal shielding. The experimental setup consisted of a conventional fast-slow coincidence system with a time-to-amplitude converter for selecting time resolution. The data were accumulated on a PDP15 computer. The

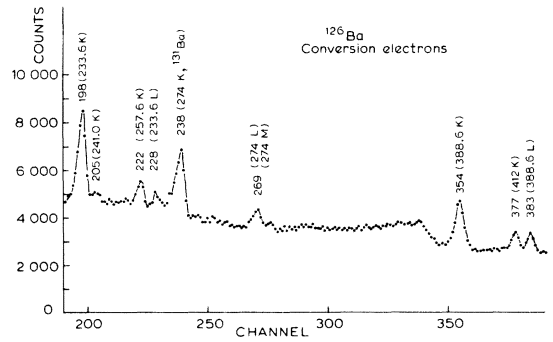

FIG. 3. A conversion electron spectrum of ^{126}Ba as measured with a cooled Si(Li) detector.

TABLE II. Conversion coefficients of ^{126}Ba γ rays deduced from observed conversion electron spectra.

Conversion electron energy (keV)	Identification E_γ shell	I_γ	α_K	Multipolarity
197.5±0.5	233.6, K	48.2	0.088	$E2,M1$
205±1	241.0, K	14.7	0.027	$E1$
221.5±0.5	257.6, K	18.7	0.053	$E2,M1$
228±1	233.6, L	48.2	0.016	$E2,M1$
354.0	388.6, K	100	0.016	$E2$

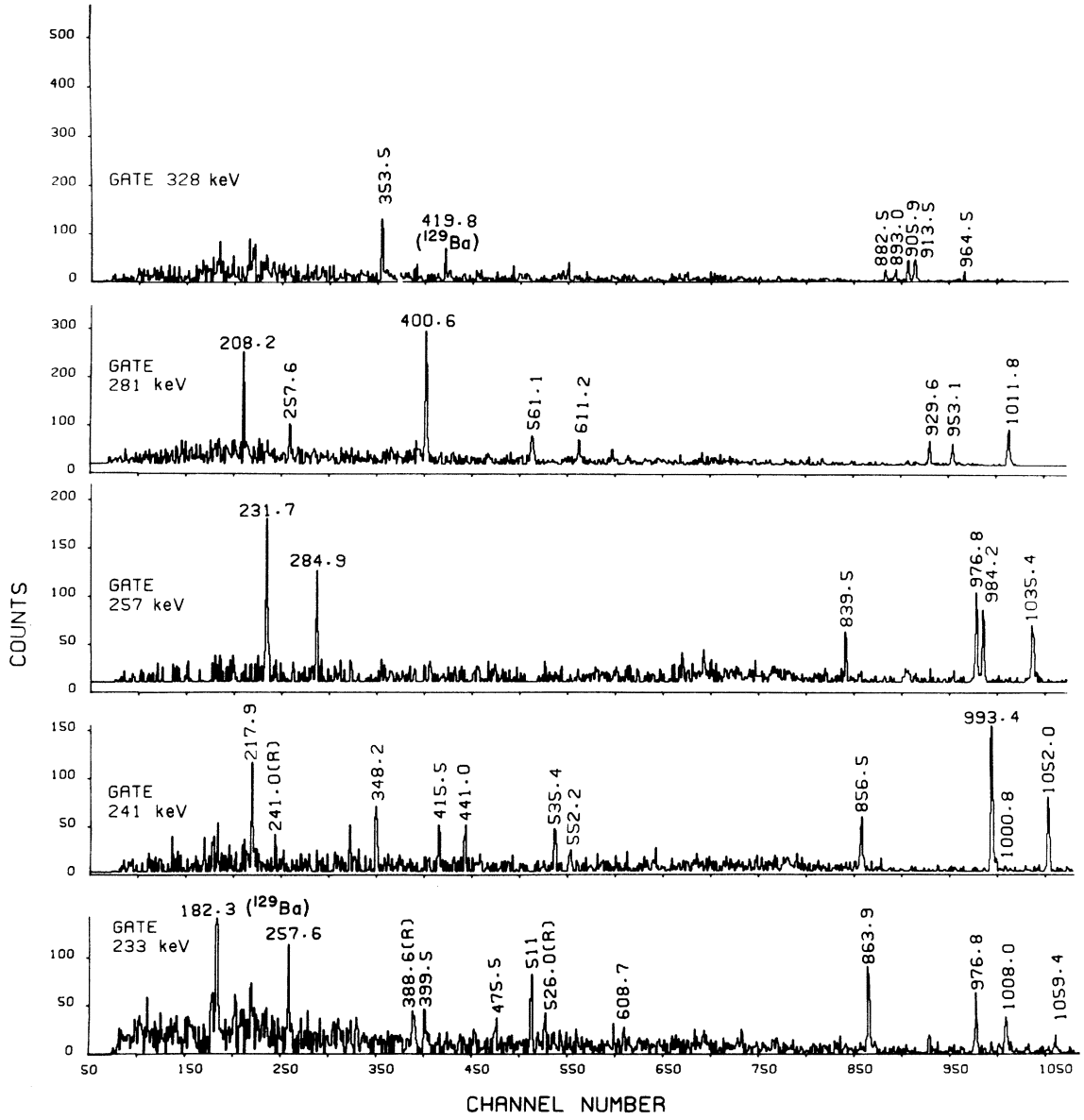

FIG. 4. γ-ray spectra in coincidence with the 233, 241, 257, 281, and 328 keV γ rays in the decay of ^{126}Ba.

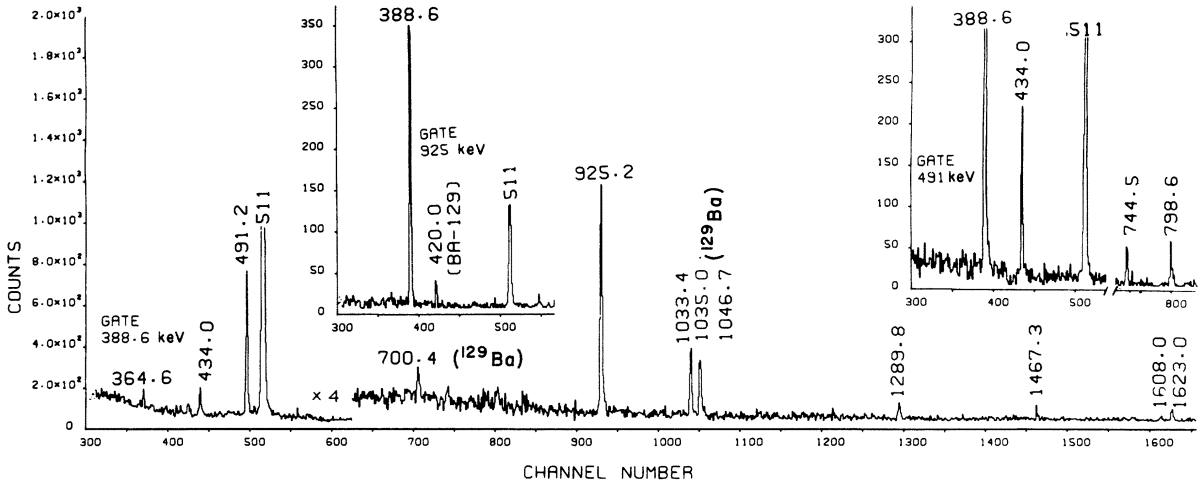

FIG. 5. γ-ray spectra in coincidence with the 388, 491, and 925 keV γ rays in the decay of ^{126}Cs.

TABLE III. Results of γ-γ coincidence measurements in the decay of ^{126}Ba.

Gate E_γ (keV)	Coincident γ rays E_γ (keV)
106.9	129.7, 217.9
129.7	106.9, 217.9
217.9	106.9, 129.7, 239.3, 290.8, 643.0, 685.6
233.6	94.7, 257.6,[a] 475.5, 548.5, 608.5, 863.9, 977.2,[b] 1000.8, 1008.0, 1059.4
241.0	217.9,[c] 348.5, 415.5, 441.0, 535.4, 551.2, 856.5, 993.4, 1052.0
257.6	231.7, 284.9, 839.9, 976.8,[b] 984.2, 1035.4
281.2	208.2, 400.6, 561.1, 929.6, 953.1, 1011.8
328.3	353.5, 548.5, 882.5, 905.9, 913.5, 964.5
348.5	241.0, 551.2
400.6	281.2, 415.5
489.3	192.5, 744.5
538.9	126.5, 303.0, 702.9
542.5	667.8, 691.9, 699.0
681.8	415.5, 611.2
709.8	583.2
781.5	452.8
839.5	257.6
842.3	392.5
863.9	233.6
976.8	233.6, 257.6
1052.0	241.0
1097.5	...
1234.4	...
1241.0	...
1293.0	...

[a] The 257.6 keV peak occurs in coincidence with the 233.6 keV gate due to the presence of the 231.7 keV photopeak in the gate.

[b] The coincidence experiments reveal that the 976.8 keV γ ray consists of two γ rays with energies very close to each other. One of the components is in coincidence with the 233.6 keV gate and the other one is in cascade with the 257.6 keV transition. The relative intensities of the components in coincidence with the 233.6 and 257.6 keV rays were estimated to be 1.6 and 4.4, respectively.

[c] The 217.9 keV γ ray is seen in coincidence with the 241.0 keV gate because a part of the intensity of the 239.3 keV photopeak is also present in the gating window.

TABLE IV. Results of γ-γ coincidence measurements on the decay of ^{126}Cs.

Gate E_γ (keV)	Coincident γ rays E_γ (keV)
388.6	364.6, 434.0, 491.2, 553.4, 798.6, 925.2, 1033.4, 1289.8, 1608.0, 1623.0, 1674.5, 1958.5
491.2	388.6, 434.0, 798.6, 1608.0, 1623.0
925.2	388.6, 1033.4
1674.5	388.6
1678.4	...
2067.3	388.6

overall time resolution was 40 ns. Digital gates were set on the photopeaks of all the intense γ rays. For each photopeak selected in a gate, another gate was set on the adjacent Compton background in order to correct for coincidence events caused by the presence of this background under the photopeak. Some typical background subtracted coincidence spectra are shown in Figs. 4 and 5. The results of the numerical analysis are listed in Tables III and IV.

The 977 keV transition was observed to be in coincidence with both the 233.6 and 257.6 keV gates. This result was further confirmed by analyzing the coincidence spectrum gated on the 977 keV photopeak. Both the 257.6 and 233.6 keV γ rays were observed. This revealed that the 976.8 keV peak observed in the singles γ spectra consists of two components with energies very close to each other. In further analyses of the coincidence spectra the energies and relative intensities (given in brackets) of these components were found to be 976.8 (4.4) and 977.2 (1.6) keV, respectively.

D. β-γ coincidence

The study of β-γ coincidences was done using extremely thin chemically separated sources. Positons were detected using a plastic scintillation detector telescope.[27] An 18% Ge(Li) detector was used for γ spectra. The performance of the system was studied using ^{47}V, ^{62}Cu, ^{64,66}Ga, and ^{63}Zn sources.

The γ-ray spectrum in coincidence with positons did not show any of the ^{126}Ba γ rays with significant intensity. However, all the intense peaks of ^{126}Cs were observed in the γ spectrum gated by the integral positon spectrum. Gates were set around the 388.6, 491.2, and 925.2 keV photopeaks and their adjacent Compton backgrounds. The endpoint energy of the coincident β^+ group in coincidence with the 388.6 keV γ ray was found to be 3.4 ± 0.1 MeV. The Q^+ value for the electron capture decay of ^{126}Cs comes out to be 4.8 ± 0.1 MeV which is in excellent agreement with the one reported by Gonusek *et al.*[28] and Westgaard *et al.*[29] The coincidence spectrum is shown in Fig. 6.

The intensity of the β^+ branch to the ground state of ^{126}Xe was determined from the relative intensities of annihilation photons and γ rays in the spectra obtained with the source enclosed at the center of a spherical aluminum absorber of 2 cm radius. The γ rays originate from the center of the absorber whereas the annihilation photons are emitted from a distance which depends on positon energy. Therefore, the thickness of the absorber is different for annihilation photons and γ rays. Kitching[30] and co-workers have made an elaborate study of this phenomenon. We have used their data to correct the observed annihilation photon intensity. Assuming the intensity of the 388.6 keV γ ray to be 100, the annihilation photon intensity was found to be 400 ± 20. The contributions from mass chains 127-129 were subtracted by measuring annihilation photon spectra from these sources under identical conditions.

The electron capture decay energy of ^{126}Ba has been reported[31,32] to be 1.8 MeV. The electron capture to β^+ intensity ratio for the decay to the ground state of ^{126}Cs was found to be 23 : 1. This

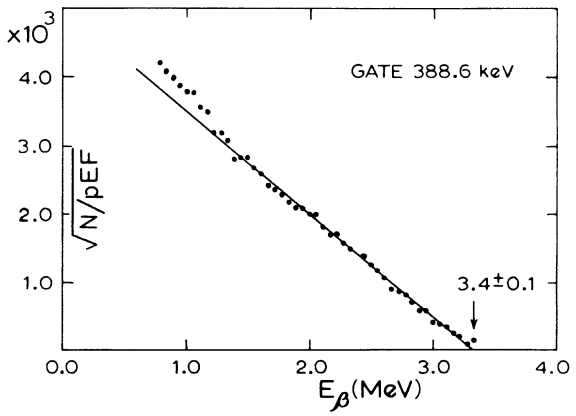

FIG. 6. Fermi-Kurie plot of the β-ray spectrum in coincidence with the 388 keV γ ray in the decay of ^{126}Cs.

ratio increases exponentially for the excited states. Therefore, we assumed the contribution from ^{126}Ba in the observed annihilation photon intensity as negligible. The β^+ branch to the ground state of ^{126}Xe was determined by subtracting the annihilation photon intensities due to β^+ branches feeding excited states of ^{126}Xe. Electron capture branches were obtained using standard graphs[33] for EC(K)/β^+ intensity ratios. The above analysis gave the intensities of β^+ and EC branches to the grounds state of ^{126}Xe as (47.8 ± 3.4)% and (7.5 ± 0.5)%, respectively.

Under equilibrium the decay rates of ^{126}Ba and ^{126}Cs nuclei should be equal. This fact has been utilized in determining the β branch to the ground state of ^{126}Cs. The EC and β^+ branches were found to be (25.5 ± 1.8)% and (1.1 ± 0.2)%, respectively.

IV. DECAY SCHEMES

A. Decay of ^{126}Ba and levels of ^{126}Cs

The decay scheme of ^{126}Ba (Fig. 7) has been constructed on the basis of the results of the γ-γ coincidence studies. A few of the weak γ rays, which could not be observed in the coincidence spectra, are included in the decay scheme between already confirmed levels with appropriate energy differences. The logft values for the electron capture branches to different levels, have been evaluated by taking the electron capture decay energy to be 1800 keV.[31,32] The absence of the ^{126}Ba γ rays in the spectrum gated by the annihilation photons provides additional support for this low decay energy. The γ rays of energies 126.5, 213.5, 269.3, and 779.0 keV could not be placed in the decay scheme, because of the lack of evidence for their cascade relationships with other transitions.

The nuclide ^{126}Ba, and even-even nucleus (Z = 56, N = 70), has a ground state spin of 0$^+$. The ground state spin of ^{126}Cs has been suggested[31] to be 1$^+$. The results of the present study give a logft of 5.4 for the decay of ^{126}Ba(0$^+$) to the ground state of ^{126}Cs. Furthermore, the intensities of the β^+ and electron capture branches of ^{126}Cs to the ground state (0$^+$) and the first excited state (2$^+$) of ^{126}Xe give logft values of 5.0 and 5.1, respectively. The above results strongly favor 1$^+$ for the spin and parity of the ground state of ^{126}Cs.

The electron capture branches to the 233.6, 681.8, 1097.5, 1210.8, 1234.4, 1241.8, and 1293.0 keV levels give logft values of 5.5, 5.7, 5.3, 5.2, 4.8, 5.2, and 4.8, respectively. These results indicate that the β decay to the above levels is of the

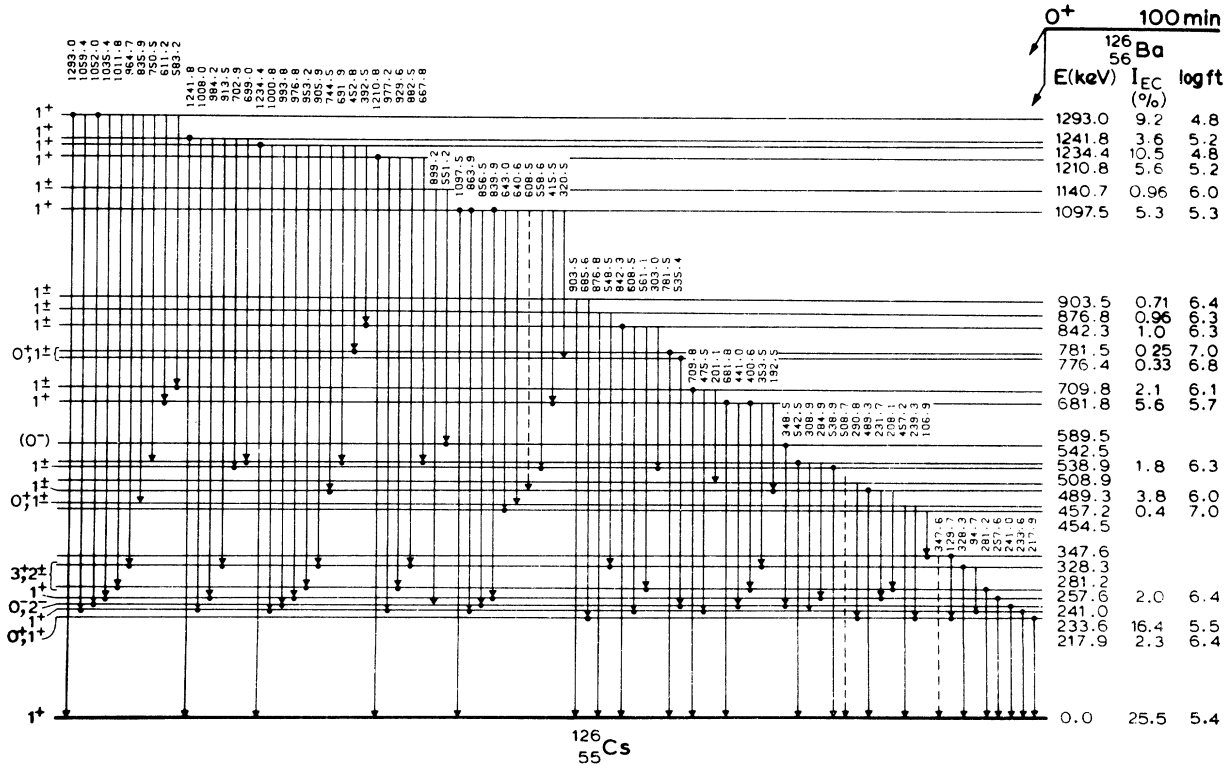

FIG. 7. The decay scheme of ^{126}Ba. Coincidence relations are indicated with a dot. The transitions whose existence could not be confirmed are shown by broken lines. The logft values were evaluated using measured intensities of electron capture branches to various levels and Q^+ = 1800 keV as given in Ref. 30.

allowed type.[34] Therefore, we have assigned 1^+ as spins and parities of these seven levels. The logft values for the electron capture decay to the levels at 217.9, 257.6, 489.3, 538.9, 709.8, 842.3, 876.8, 903.5, and 1140.7 keV were found to be 6.4, 6.4, 6.0, 6.3, 6.1, 6.3, 6.3, 6.4, and 6.0, respectively. The nature of the decay to these nine levels could be either allowed or first forbidden, and therefore, the possible spins and parities of the levels are suggested to be 1^+ or 1^-. The conversion electron data give the possible multipolarities of the 257.6 keV transition to be either $M1$ or $E2$ or else an admixture of the two, and hence, a negative parity for the 257.6 keV level is ruled out. The lower limit of the logft for the isospin forbidden $0^+ \rightarrow 0^+$ transitions has been shown[34] to be 6.5. This fact has been made use of in assigning 0^+ or 1^- spins and parities to the 457.2, 776.4, and 781.5 keV levels for which the electron capture feeding intensities yield logft values of 7.0, 6.8, and 7.0, respectively. Because of the uncertainties involved in the evaluation of the logft values, a 0^+ spin and parity assignment for the levels with a logft value of 6.4 (i.e., the 217.9 and 903.5 keV levels) is not completely ruled out.

We did not observe any significant β feeding to the 241.0, 281.2, 328.3, 347.6, 454.5, 508.9, 542.5, and 589.5 keV levels. The K conversion coefficient of the 241.0 keV transition was evaluated to be 0.020 from the conversion electron spectra. This conversion coefficient indicates an $E1$ multipolarity for the 241.0 keV transition, and therefore the possible J^π values of the 241.0 keV level are $(0, 1, 2)^-$. The absence of an electron capture branch rules out the 1^- assignment. The levels whose spins are not indicated in Fig. 7 may have J^π values of 0^-, 2^+, or 3^+.

B. Decay scheme of 1.6 min ^{126}Cs

A total of 22 γ rays have been placed in a ^{126}Xe level scheme (Fig. 8) following the decay of ^{126}Cs. The first excited state of ^{126}Xe is known to be at 388.6 keV. The γ-ray pairs with energies 879.8-491.2, 1678.4-1289.8, 2456-2067.3, and 2567-2178 keV have an energy difference of 388 keV and the low-energy member of each pair appears in coincidence with the 388 keV gate. We suggest levels at 879.8, 1678.4, 2455.9, and 2567 keV, to justify the above coincidence results. The higher-energy members of the pairs are included as crossover transitions. The 553.3 keV γ ray appears in coincidence with only the 388.6 keV gate. We included a level at 941.9 keV to accommodate this γ ray. The results of the γ-γ coincidence studies with the windows set around photopeaks at 491.2, 925.2, and 1674.5 keV indicate the existence of 1313.8, 1678.4, 2063.1, 2347.1, 2487.8, and 2502.8 keV levels. The logft values have been calculated by using the measured value

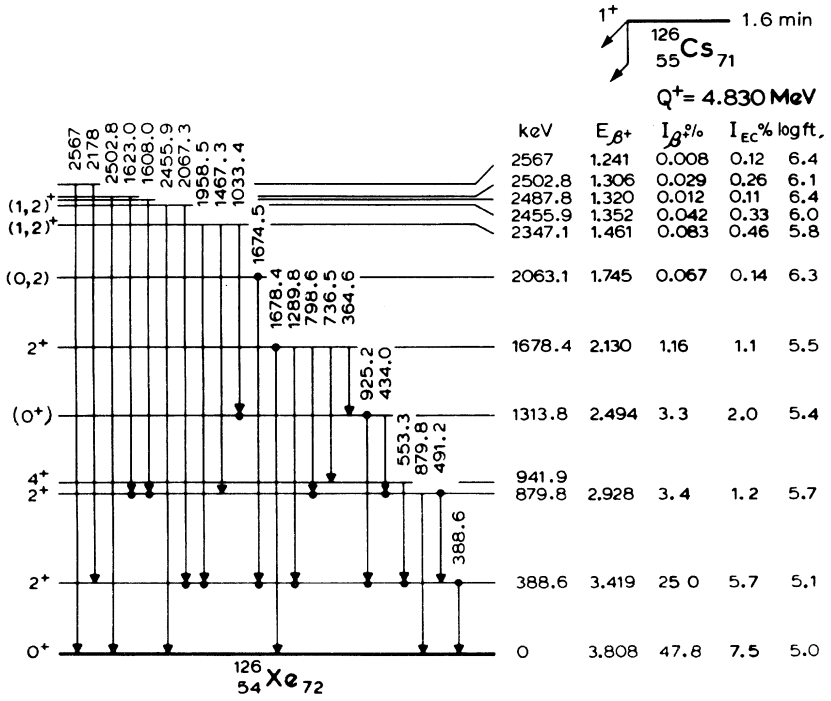

FIG. 8. The decay scheme of ^{126}Cs. The value of Q_{EC} was taken from Ref. 28.

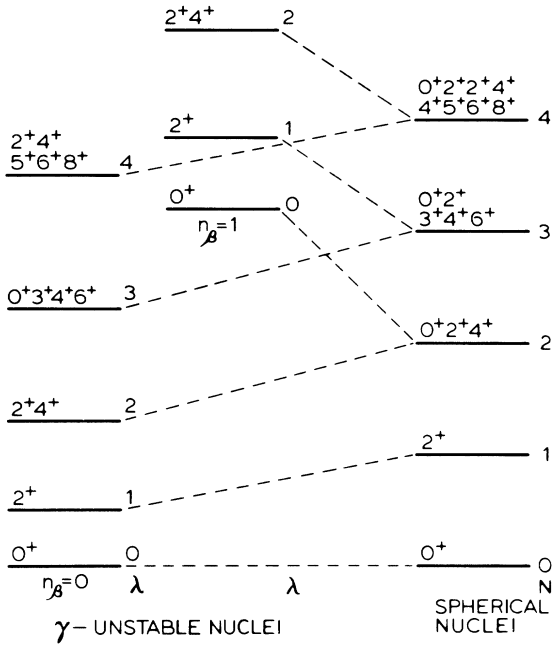

FIG. 9. The energy level spectrum of spherical ($\beta_0 = 0$) and γ-unstable ($\beta_0 \gg 0$) nuclei according to the Wilets-Jean model.

of the Q_{EC} and the standard graphs[33] for EC(K)/β^+ ratios.

The nucleus ^{126}Xe has even numbers of protons and neutrons and hence, has a 0^+ ground state spin. The excited states at 388.6 and 879.8 keV are known[33] to have spin 2^+. The 941.9 keV level seems to be the same as the one identified by Bergstrom *et al.*,[35] and confirmed as a 4^+ excited state by Kusakari *et al.*[36] In the present work we do not see any direct β feeding to this level. Furthermore, no γ transition from this level to the ground state was observed. These results strongly support the 4^+ spin assignment. The intensities of the electron capture and position branches to the 1313.8 keV level give a logft of 5.4, indicative of an allowed β transition. Therefore, the possible J^π value of this level would be $(0,1,2)^+$. The absence of a γ transition to the ground state rules out 1^+ and 2^+ spins. The 1313.8 keV level proposed in the present study is not the same as the 1317.3 keV (3^+) excited level observed by Kusakari *et al.*[36] for two reasons. Firstly, the observed logft value of 5.4 cannot be explained with a 3^+ spin assignment to the 1313.8 keV level and secondly, the γ-decay properties of the 1317.3 keV level are different from those observed in this work. The 1678.4 keV level is fed by an allowed β transition and decays to the ground and first excited states by prompt γ emission. The probable spins for this level are 1^+ or 2^+. The intensity of the 736.5 keV transition between the 1678.4 and 941.9 (4^+) levels cannot be explained with a 1^+ J^π value and hence, we suggest a 2^+ spin for the 1678.4 keV level. The possible spins and parities of some of the remaining levels are suggested on the basis of the deduced logft values only.

The sequence of the low lying excited states of ^{126}Xe with spins and parities of $0^+_{g.s.}, 2^+, 2^+, 4^+$ is consistent with the trend observed for the even-even nuclei. In this mass region, Kusakari *et al.*[36] have identified the second 2^+ level as the bandhead for the quasi-γ band. The identification of the first 0^+ excited state at 1313.8 keV is consistent with the experimental results in the neighboring even-even nuclei[37,38] where the first 3^+ and 0^+ excited states are found to be very close in excitation energy, but poses interesting theoretical problems. Habs and co-authors have predicted the excitation energy of the first 0^+ level in ^{126}Xe to be 2094 keV, using the generalized collective model of Gneuss and Greiner.[15] The presence of a 0^+_2 level at 1314 keV would be contrary to their prediction of the rising of the 0^+_2 level with increasing distance from the closed shell with $N = 82$. Rohozinski, Srebrny, and Horbaczewska[6] have studied the structure of

TABLE V. Comparison of theoretical and experimental $B(E2)$ values in even Xe nuclei. The levels are identified by quantum numbers n_β, λ, I (see Ref. 6).

	^{126}Xe		^{128}Xe	
$B(E2)$ ratio	Experiment (present work)	Theory [a]	Experiment [a]	Theory [a]
$\frac{B(E2,022\rightarrow 000)}{B(E2,022\rightarrow 012)}$	0.016 ± 0.003	0.019	0.014	0.020
$\frac{B(E2,100\rightarrow 012)}{B(E2,100\rightarrow 022)}$	0.096 ± 0.015	8		0.36
$\frac{B(E2,030\rightarrow 012)}{B(E2,030\rightarrow 022)}$	0.096 ± 0.015	0.006	0.21	0.14

[a] Reference 6.

the even mass Xe nuclei using the Wilets-Jean Hamiltonian, including a term giving oblate-prolate asymmetry. The energy level structure obtained with this model is shown schematically in Fig. 9. The energy levels for the γ-unstable nuclei are labeled with the quantum numbers n_γ, λ, I where I is the spin of the level, $n_\beta = 0, 1, 2 \ldots$ is the β-vibrational quantum number. The ordering of the levels in a band with fixed n_β is given by λ, referred to as "seniority." For spherical nuclei, the phonon number $N = 2n_\beta + \lambda$.

According to the results reported by Rohozinsky *et al.*,[6] the first excited 0^+ state could be either a β-vibrational level with $n_\beta = 1$ and $\lambda = 0$, or a 0^+ state with $n_\beta = 0$ and $\lambda = 3$. The nature of this level could in principle be determined from the γ-transition probabilities which differ for the two levels. We tried to identify the proposed 0^+ state at 1314 keV by comparing with Rohozinski *et al.*[6] with those deduced from the experimental data obtained in this work. The results are shown in Table V. The observed γ decay characteristics of the 1314 keV level are intermediate between those calculated for the two above mentioned states but appear to agree very closely with the predicted values for the $n_\beta = 0$, $\lambda = 3$ state in ^{128}Xe.

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