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Rotational bands in ^{79}Kr

S M BHARATHI*, Y K AGARWAL*, B LAL*, C V K BABA†, M G BETIGERI† and N G PUTTASWAMY**

* Tata Institute of Fundamental Research, Bombay 400005
† Bhabha Atomic Research Centre, Bombay 400085
** Department of Physics, Bangalore University, Bangalore 560001

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Abstract. The level scheme of ^{79}Kr has been studied through the ^{79}Br(p,n)^{79}Kr reaction at proton energies from 1·7 to 5·0 MeV. γ-ray and internal conversion electron measurements were made using Ge(Li) detectors and a six gap "Orange" electron spectrometer. The level scheme was established by determining the thresholds of various γ-rays and by γ–γ and n–γ coincidence measurements. New levels at 402, 450, 660, 676, 695, 720, 810, 836, 907 and 1038 keV not observed in earlier radioactivity studies have been established. Definite J^π assignments have been made to most of the levels below 800 keV. Many of the low-lying levels are identified as rotational levels based on the (301 ↓) 1/2$^-$, (301 ↑) 3/2$^-$ and (431 ↓) 1/2$^+$ Nilsson states.

Keywords. Nuclear reaction: ^{79}Br(p, n)^{79}Kr; level scheme; internal conversion coefficients; J^π; nuclear structure; deformation; Nilsson states.

1. Introduction

The level structure of odd neutron nuclei in the Se–Kr region shows several interesting features. The anomalous nature of the positive parity levels and the possibility of fitting several of the negative parity levels into rotational bands have been discussed in an earlier work on the level scheme of ^{75}Se (Agarwal *et al* 1974). In the present paper, a detailed level scheme of ^{79}Kr studied through the gamma-ray and conversion electron spectroscopy following the ^{79}Br(p, n) ^{79}Kr reaction is reported. As a result, unambiguous evidence for the deformed nature of ^{79}Kr is presented.

The levels in ^{79}Kr populated in the β^+ and electron-capture decay of ^{79}Rb have been studied by Lingeman *et al* (1971), hereafter referred to as LM, and by Broda *et al* (1972). Several states up to 1 MeV excitation have been identified by these authors. In the present work, the level scheme of ^{79}Kr has been studied through the ^{79}Br (p, n) reaction. Apart from the levels already known from radioactivity studies, several additional levels which could not be populated in the decay of ^{79}Rb were observed. Spin and parity assignments to most of the 20 levels, seen in the present work and lying below an excitation energy of about 1 MeV, have been made mainly on the basis of multipolarities of the gamma transitions between these levels. The multipolarities were determined by measuring the internal conversion coefficients of the γ-transitions. A preliminary account of this work was reported earlier (Agarwal *et al* 1972).

2. Experimental procedure

Using the 5·5 MeV Van de Graaff accelerator at BARC, Trombay, the following experiments were performed in order to determine the level scheme:

(i) Singles γ-ray spectroscopy using Ge (Li) detectors,

(ii) threshold determination of various γ-transitions by measuring γ-ray excitation functions,

(iii) γ–γ coincidence studies using two Ge (Li) detectors,

(iv) n–γ-coincidence measurements using a plastic scintillator and a Ge (Li) detector, and

(v) internal conversion spectroscopy using a six gap " Orange " β-ray spectrometer.

The apparatus and the experimental methods have been described earlier (Agarwal *et al* 1974). A brief description of the same, with special reference to the present work, is presented below.

2·1. *Target preparation*

Natural Br targets in the form of KBr weie used in the present experiment. Targets with thickness $\simeq 100\,\mu g\,cm^{-2}$ were prepared by vacuum evaporation on to thin ($\simeq 30\,\mu g\,cm^{-2}$) carbon or gold backings. Since natural bromine contains ^{79}Br and ^{81}Br in about equal amounts, it was necessary to ascertain the origin of the various γ-transitions observed and assign them to one of the two isotopes of bromine. This was done by repeating some of the measurements with 99·6% enriched ^{81}Br targets prepared in a similar manner.

2·2. *Singles and coincidence γ-ray spectroscopy and excitation function studies*

Singles γ-spectra were taken with a 30 cm³ Ge (Li) detector for various bombarding energies ($E_p = 1\cdot7 - 5\cdot0$ MeV in steps of 100 keV). The observed spectra consisted of γ-rays resulting from inelastic scattering, (p, γ) and (p, n) reactions on the two Br isotopes. It was possible to identify the γ-transitions originating from (p, n) reactions by making neutron-gamma coincidence measurements. The γ-rays were detected in a Ge (Li) detector and the neutrons in a 5 cm $\phi \times 5$ cm plastic scintillator which had a 5 cm thick lead absorber in front to absorb the γ-rays. The coincidence resolving time used in this experiment was $2\tau = 200$ ns. Only the transitions originating from the (p, n) reactions would be seen in the coincidence spectra.

Gamma-ray spectra were also taken at a few proton energies with the enriched ^{81}Br targets. Since the (p, n) Q-values for ^{79}Br and ^{81}Br are quite different ($-2\cdot402$ and $-1\cdot084$ MeV respectively), a comparison of γ-ray spectra for proton energies below and above the (p, n) threshold for ^{79}Br also helped in determining the origin of many transitions. As a result of these studies, it was possible to ascertain the origin of most of the observed γ-rays. A γ-ray spectrum taken at $E_p = 4\cdot0$ MeV along with the identification of the observed transitions is shown in figure 1. All the singles γ-ray spectra were taken with the detector kept at an angle $\theta \simeq 60°$

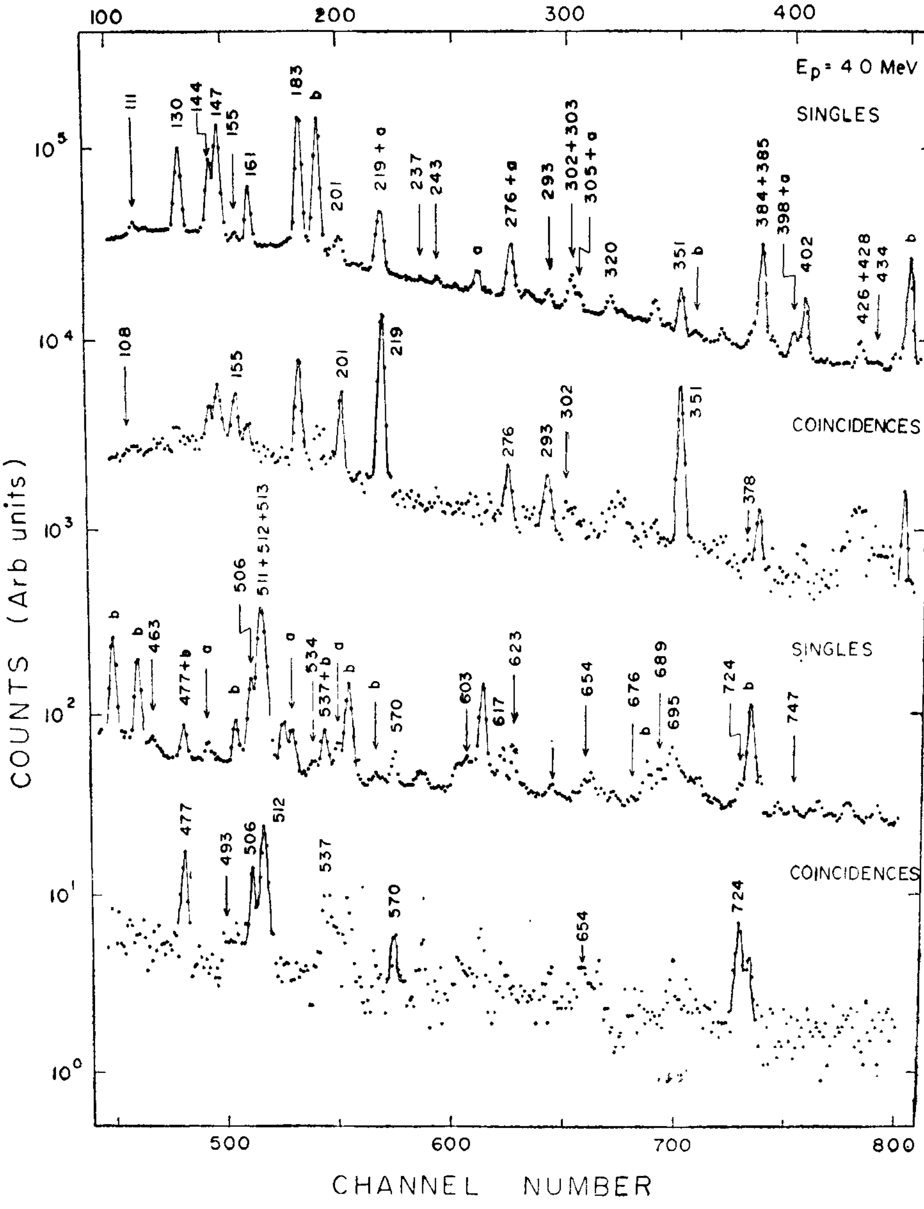

Figure 1. A singles γ-ray spectrum and a coincidence γ-ray spectrum using two 30 cc Ge(Li) detectors with the 183 keV peak in the gate obtained by bombardment of a natural KBr target at $E_p = 4{\cdot}0$ MeV. The numbers indicate the energies of the γ-rays rounded off to the nearest keV. The lines marked 'a' arise from (p, p′) and (p, γ) reactions while those marked 'b' are from the ^{81}Br(p, n)^{81}Kr reaction. The counts for the lower two curves are to be multiplied by 100.

Table 1. List of γ-rays from the ^{79}Br(p, n)^{79}Kr reaction at $E_p = 5.0$ MeV

$E_\gamma{}^a$ (keV)	Threshold^b E_p (MeV)	Assignment (keV→keV)		$\alpha_K{}^c$
17	..	147	130	
108*	..	291	183	0·3
111	..	402	291	
130	2·7	130	0	1·9±0·1
144	2·8	291	147	7·7±3·0 (−2)
147	2·6	147	0	1·8±0·1 (−1)
155	3·2	689	534	
161	2·8	291	130	2·4±0·6 (−2)
183	2·7	183	0	3·0±0·3 (−2)
201	2·8	384	183	
219	..	402	183	2·0±0·5 (−2)
237	2·8	384	147	1·4±0·7 (−2)
243	..	932	689	
276	..	660	384	7·5±1·0 (−3)
291*	..	291	0	
293	3·3	695	402	(2·9±1·4) (−3)
302*	..	836	534	
303	2·9	450	147	1·1±0·7 (−2)
305	..	689	534	
320	2·9	450	130	3·0±0·4 (−3)
351	3·0	534	183	2·0±0·4 (−3)
378*	..	1038	660	
384	2·9	384	0	3·4±0·2 (−3)
385*	..	676	291	
398	..	689	291	
402	2·9	402	0	5·4±0·8 (−3)
426	3·2	810	384	
428	..	720	291	

$E_\gamma{}^a$ (keV)	Threshold^b E_p(MeV)	Assignment (keV→keV)		$\alpha_K{}^c$
434	..	836	402	
452*	..	836	384	
463	..	753	291	
477	..	660	183	
493*	..	676	183	
506	3·1	689	183	
512*	..	695	183	
513*	..	660	147	
534	..	534	0	
537	..	720	183	
542*	..	689	147	
570	..	753	183	
603	..	987	384	
617	..	907	291	
623	3·2	753	130	1·0±0·3 (−3)
654	3·5	1038	384	
676	3·2	676	0	
689	..	689	0	
695	..	695	0	
724	..	907	183	
747	3·5	1038	291	
803	..	987	183	
810	..	810	0	
891	..	1038	147	
908	3·5	1038 (907	130; 0)	
931	3·5	932	0	
988	..	987	0	

* The γ-rays observed mainly through γ-γ coincidence measurements.

a The energies have been rounded off to the nearest keV.

b The lowest proton energy at which the γ-ray was observed.

c The numbers in the bracket in this column indicate the power of the multiplicative factor 10.

Table 2. The observed γ-γ coincidence relationships

E_γ in gate (keV)	E_γ in coincidence (keV)
147	.. 111, 144, 237, 303, 385, 398, 428, 463, 513, 542, 617, 891
155+161	.. 111, 183, 243, 351, 385, 398, 428, 463, 534, 617.
183	.. 108, 155, 201, 219, 276, 293, 302, 351, 378, 385, 426, 452, 577, 493, 506, 512, 537, 570, 603, 654, 724, 803.
219	.. 183, 293, 434.
293	.. 111, 183, 219, 402.
302+303+305	.. 147, 243, 351, 384.
351	.. 155, 183, 243, 302.
384+385	.. 108, 144, 147, 161, 183, 276, 291, 378, 426, 452, 603 654.

with respect to the beam direction in order to minimise the angular distribution effects.

The γ-ray excitation function data were used to attribute various transitions to the different levels. It was also ascertained that the relative intensities of the different transitions assigned as decaying from the same level are independent of the proton bombarding energy. A list of γ-transitions originating from the ^{79}Br (p, n) ^{79}Kr reaction, along with their approximate threshold energies and placement in the level scheme is given in table 1.

A series of γ-γ coincidence spectra were recorded using two 30 cm^3 Ge (Li) detectors with a coincidence resolving time $\simeq$ 200 ns. A summary of the coincidence relationships of the various transitions is given in table 2. A typical γ-γ coincidence spectrum is also shown in figure 1. Several weak γ-transitions which could not be observed in the singles spectra were observed in the coincidence spectra and these are marked in table 1 with an asterisk.

2·3. *Internal conversion electron spectra*

The internal conversion electron spectra were taken with a six gap " Orange " spectrometer with $\simeq$ 6% transmission at $\simeq$ 1% momentum resolution. An automatic scanning system in which the spectrometer current was varied within two chosen limits was used. This minimised the variation in the background from one measured point to another. One such spectrum taken at $E_p = 5 \cdot 0$ MeV is shown in figure 2. The internal K-conversion coefficients were determined in a manner described earlier (Agarwal *et al* 1974) with the theoretical K-conversion coefficient of the 191 keV E3 transition in ^{81}Kr excited through the ^{81}Br (p, n)^{81}Kr reaction taken to be a standard for normalisation purposes. The K-conversion coefficients of the 144 keV and 183 keV transitions could not be determined reliably from these spectra since the two K-lines are not very well separated from the L–130 keV and K–191 keV lines. To determine these conversion coefficients more reliably a conversion-electron spectrum in coincidence with neutrons of energy more than 50 keV was recorded. Since the 130 keV and the 191 keV transitions arise from

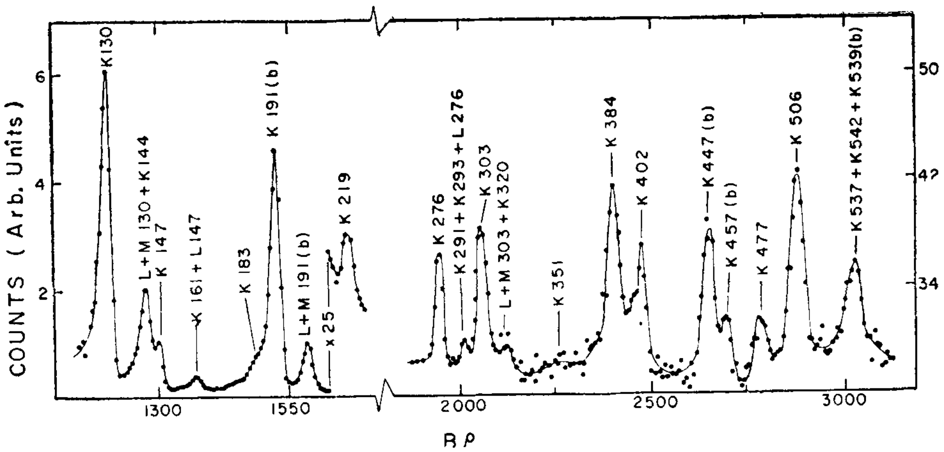

Figure 2. The conversion electron spectrum recorded with the six gap electron spectrometer at $E_p = 5\cdot0$ MeV. The lines marked 'b' arise from the ^{81}Br(p, n) reaction.

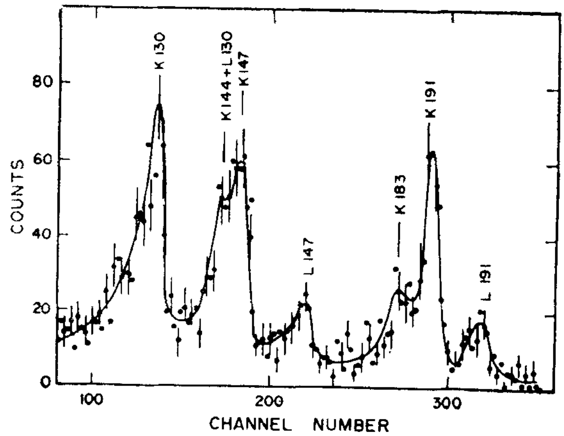

Figure 3. Conversion electron spectrum in coincidence with neutrons of energy more than 50 keV recorded with the six gap electron spectrometer at $E_p = 5\cdot0$ MeV. The chance coincidences have not been subtracted.

levels with very long half-lives (55 s and 13 s respectively), these two lines would not be coincident with the neutrons. The resulting spectrum is shown in figure 3. The relative intensities of the K-conversion lines of the 144, 147 and 183 keV transitions were determined from this spectrum. Using the measured value of the K conversion coefficient of the 147 keV transition, the values of α_K's for the 144 and 183 keV transitions were determined.

The measured K-conversion coefficients are compared with the theoretical values for different multipolarities (Hager and Seltzer 1968) in figure 4. The multipolarities of the various transitions were determined from this comparsion.

Level scheme

The level scheme of ^{79}Kr constructed on the basis of measurements described above is shown in figure 5. The new levels proposed in this work are 402 keV ($5/2^-$), 450 keV ($7/2^-$), 660 keV ($5/2^-$), 676 keV ($3/2^+$), 695 keV ($3/2^+$), 720 keV ($7/2^*$),

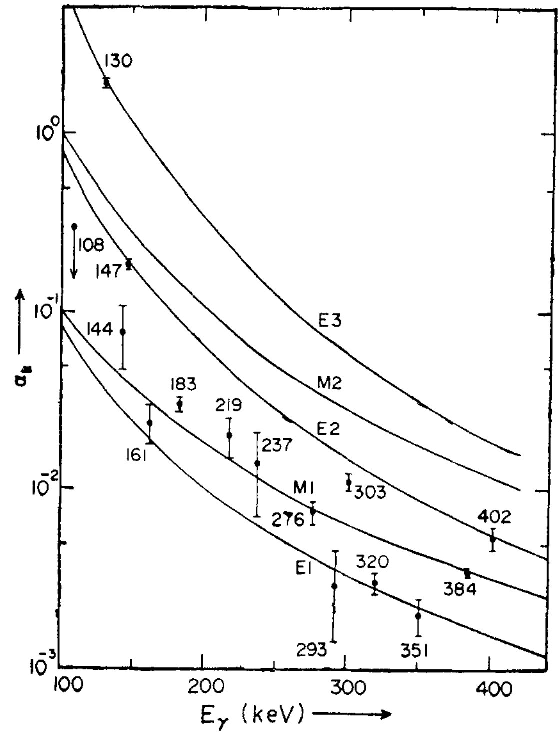

Figure 4. Comparison of the measured values of internal conversion coefficients (α_K) with theoretical values. The continuous lines are the values of α_K taken from Hager and Seltzer (1968) for various multipolarities.

810 keV, 836 keV ($5/2^+$), 907 keV and 1058 keV ($7/2^-$) levels. The individual levels are briefly discussed below along with the arguments for assigning the spins and parities.

Ground state—The ground state is known to have the spin $\frac{1}{2}^-$ (LM).

The 130 keV level—The E3 nature of the 130 keV transition inferred in the present work and in the previous works (Isolde Group CERN 1969) establishes the spin and parity of the 130 keV state as $7/2^+$.

The 147 keV level—The E2 nature of the 147 keV transition (*see* figure 4) confirms a $5/2^-$ assignment to this level, made earlier by LM. However, LM reported a 17 keV transition from this level to the 130 keV ($7/2^+$) level. A search was made for this transition in coincidence with the 144 keV transition. This measurement could not confirm the existence of the 17 keV transition and yielded an upper limit of 35% for the branching ratio for the 17 keV transition in disagreement with the value $\simeq$ 65% given by LM.

The 183 keV level—The multipolarity of the 183 keV ground state transition from his level was measured to be M1 + (12 $\pm$ 5)% E2. This suggests a spin $3/2^-$ to this level. The possibility of a $\frac{1}{2}^-$ assignment with a small E0 admixture in the 183 keV transition is ruled out from the fact that the 108 keV transition from the 291 keV ($5/2^-$) level (see below) has been found to have an α_K much smaller than

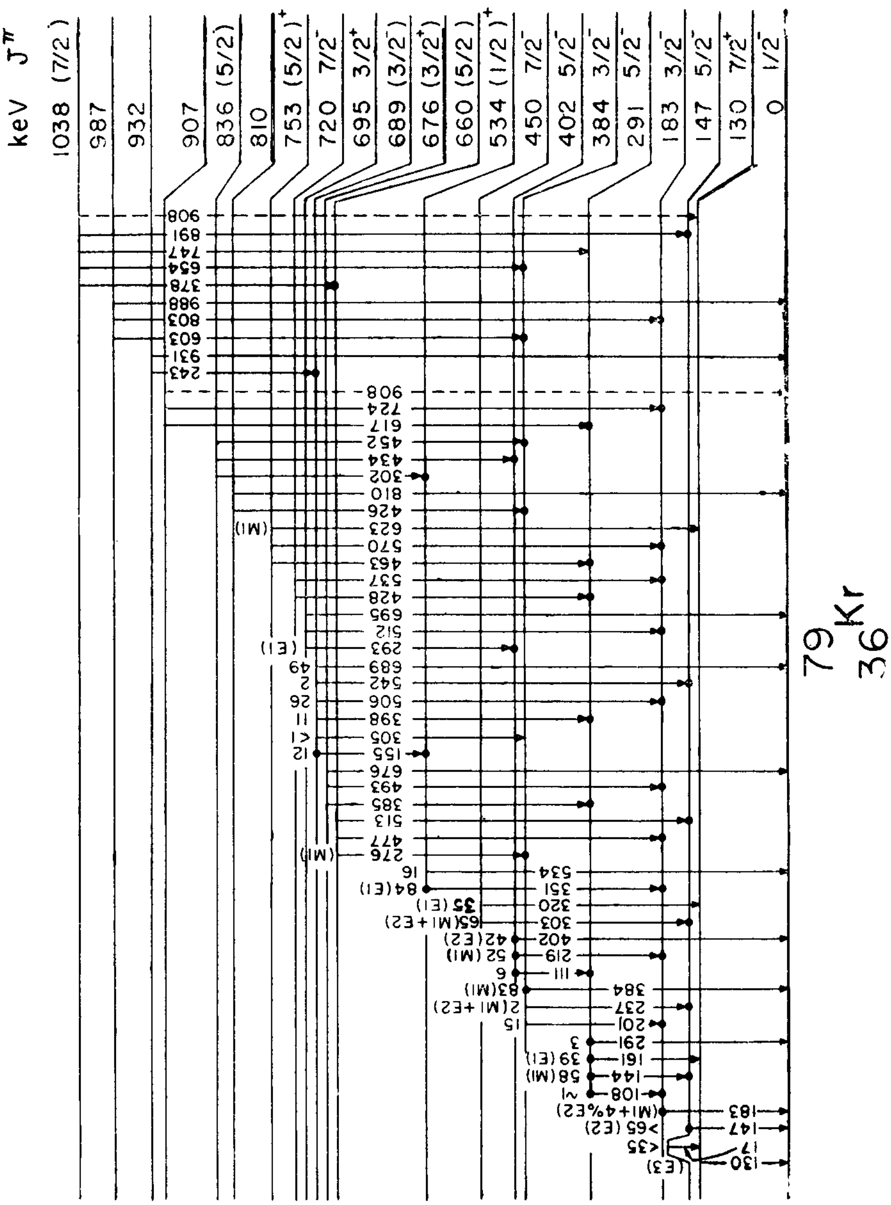

Figure 5. Proposed level scheme of ^{79}Kr. The branching ratios and multipolarities wherever determined are indicated on the top of the corresponding transitions.

the theoretical value for an E2 transition. An upper limit of 0·6 ns has been reported by Broda *et al* (1972) for the half-life of this level, yielding an E2 enhancement factor > 20 for the 183 keV transition. We could not observe the 53 keV transition from this level to the 130 keV level reported by LM. The present measurements rule out the $3/2^+$ and $5/2^-$ assignments to this level made by LM and Broda *et al* (1972) respectively.

The 291 keV level—This level has been reported earlier by LM and Broda *et al* (1972). We confirm the $5/2^-$ assignment to this level on the basis of the multipolarities of the 144 and 161 keV transitions. In addition a weak $(3 \pm 2)\%$ branch to the ground state not reported earlier was also observed in our coincidence studies.

The 384 keV level—In addition to the ground state and a 201 keV transition reported by earlier workers, a weak 237 keV γ-ray has been found to originate from this level on the basis of γ–γ coincidence measurement. The fact that the multipolarity of the 384 keV transition feeding the ground state $(1/2^-)$ is M1 and that of the 237 keV transition feeding the 147 keV $(5/2^-)$ level is M1 + E2 establishes the spin and parity for this level to be $3/2^-$.

The 402 keV level—This level is proposed on the basis of the observation of a strong coincidence between the 183 and 219 keV transitions. A γ-ray of energy 402 keV which was assigned the multipolarity E2 on the basis of the measured value of α_K was also found to originate from this level on the basis of the threshold measurements. A weak 111 keV transition from this level to the 291 keV level was observed in coincidence with the 161 keV transition. The multipolarity of the 302 keV transition and the decay mode of this level suggest a $5/2^-$ assignment for this level.

The 450 keV level—This level is proposed on the basis of the 147–303 keV γ–γ coincidences and the observation of a 320 keV γ-transition. The relative intensities of the 303 and 320 keV transitions were found to be independent of the bombarding energy of the protons, showing that these two transitions originate from the same level. The measured multipolarities of the 303 keV transition (M1 + E2) and the 320 keV transition (E1) together with the absence of decay to the ground $(1/2^-)$ state and the 183 keV $(3/2^-)$ level suggest a spin $7/2^-$ to this level. This spin assignment is also supported by the absence of β^+ feed to this level in the decay of ^{79}Rb which is presumably $3/2^-$ (LM).

The 534 keV level—This level was proposed by LM. Our γ–γ coincidence measurements support the existence of this level. The measured E1 nature of the 351 keV transition from this level to the 183 keV $(3/2^-)$ level fixes the parity of this level to be positive. Since this level decays to the ground state $(1/2^-)$, the 183 keV level $(3/2^-)$ but not to the 147 keV level $(5/2^-)$ and the 130 keV level $(7/2^+)$, a $1/2^+$ assignment was made to this level.

The 660 keV level—This level is proposed on the basis of the 276–384 keV, 477–183 keV and 513–147 keV γ–γ coincidences. Although the thresholds for the various transitions decaying from this level could not be determined due to the presence of interfering γ-rays of similar energies but having an origin different from the ^{79}Br (p, n) reaction, the above-mentioned coincidence data establish this level unambiguously. Since this level decays by the 276 keV (M1 + E2) transition to the 384 keV ($3/2^-$) level and also to the 183 keV ($3/2^-$) and the 147 keV ($5/2^-$) levels but not to the ground state ($1/2^-$), a $5/2^-$ assignment seems definite for this level.

The 676 keV level—This level is proposed on the basis of the observations of the 385–161 keV and 493–183 keV $\gamma-\gamma$ coincidences. In view of the decay of this level to the ground state ($1/2^-$), the 183 keV ($3/2^-$) and the 291 keV ($5/2^-$) levels, a 3/2 assignment could be made for this level. The absence of β^+ feed to this level would indicate this level to be a positive parity state.

The 689 keV level—This level was proposed by LM. The decay of this level to the 534 ($1/2^+$), 291 ($5/2^-$), 183 ($3/2^-$), 147 keV ($5/2^-$) levels and to the ground state ($1/2^-$) indicate the possibility of $1/2^-$ and 3/2 spin for this level. The 506 keV transition shows an abnormally large K-conversion coefficient. An E0 admixture in the 506 keV transition cannot be ruled out. If this explanation of the presence of an E0 admixture is correct the spin of this level would be $3/2^-$. A weak 305 keV transition from this level to the 384 keV level is shown in figure 5 on the basis of the observation of LM.

The 695 keV level—This level is proposed on the basis of the existence of a 293 keV γ-ray coincident with the 219 keV γ-ray. This level also decays to the ground state ($\frac{1}{2}^-$) and the 183 keV ($3/2^-$) level. The multipolarity of the 293 keV transition to the 402 keV ($5/2^-$) level was determined to be E1 on the basis of its α_K value and so the parity of the 695 keV level is positive. On the basis of its decay mode, a spin of $3/2^+$ can be assigned to this level.

The 720 keV level—This level is proposed on the basis of the presence of a 537 keV γ-ray in coincidence with the 183 keV γ-ray. This level also decays to the 291 keV ($5/2^-$) level by a 428 keV transition as seen in coincidence with the 161 keV transition. The value of α_K for the 537 keV transition could not be reliably determined due to the presence of interfering transitions of similar energies which could not be resolved. However, an E2 assignment is not inconsistent with the data, whereas an E1 assignment can be ruled out. This fact along with the absence of a ground state transition from this level suggests an assignment of $7/2^-$ to this level.

The 753 keV level—This level was proposed by LM, who placed a 219 keV transition from this level to the 534 keV level and a 603 keV transition to the 147 keV level. Both these placements are ruled out on the basis of our γ–γ coincidence data. However, the placement of the 463 keV and 570 keV transitions by them is confirmed. In addition, one more γ–ray of energy 623 keV feeding the 130 keV level has been found to originate from this level on the basis of threshold determination. The α_K measurement of the 623 keV transition shows this to be of M1 character (not shown in figure 4). The mode of decay of this level and the multipolarity of the 623 keV transition fix the spin and parity of this level to be $5/2^+$.

The 810 keV level—This level is proposed on the basis of observation of a 426 keV γ-ray in coincidence with the 384 keV γ-ray. In addition, the observed threshold of the 426 keV γ-ray confirms its origin. This level also decays to the ground state.

The 836 keV level—The evidence for the existence of this level comes from the 434–219 keV and 452–384 keV γ–γ coincidences seen in the present work. The assignment of the 302 keV γ-ray from this level is based on the observed 302–183 keV coincidences. The threshold of the 302 keV γ-ray could not be determined due to the presence of a strong 303 keV γ-ray deexciting the 450 keV level. The mode of decay of this level to the lower states and the fact that it is not populated in β^+-decay of ^{79}Rb suggest a spin of $5/2^+$ for this level.

The 907 keV level—There are two transitions from this level (617 and 724 keV) which are based on the 617–161 and 724–183 keV coincidences. The ground state transition from this level is shown as dotted in figure 5 as its threshold could not be determined unambiguously.

The 932 keV level—LM proposed this level and attributed six transitions to the level. However, we have found evidence only for two transitions, *viz.*, the ground state and the 243 keV (932 keV $\rightarrow$ 689 keV) transitions. The 932 keV γ-ray has the proper threshold. The placement of the 243 keV transition is based on the γ–γ coincidence data.

The 987 keV level—This level decays to the ground state, the 183 and 384 keV levels. The 803 and 603 keV γ-rays are found to be coincident with the 183 and 384 keV γ-rays respectively.

The 1038 keV level—This level is proposed mainly on the basis of γ–γ coincidence measurements. There are five transitions from this level: 908, 891, 747, 654 and 378 keV to the 130, 147, 291, 384 and 660 keV levels respectively. The placement of the 908 keV γ-ray is uncertain. A conversion electron spectrum taken in the energy region 500 to 700 keV gives an upper limit of α_K consistent with the value for an E2 transition for the 654 keV γ-ray. In view of this fact and the mode of decay of this level, a $(7/2^-)$ spin assignment is suggested for this level.

4. Discussion

In this work, spins and parities of most of the levels up to $\simeq$ 800 keV have been determined. The only levels which have unambiguously been assigned a positive parity are the 130 keV $(7/2^+)$, 534 keV $(1/2^+)$ and the 695 keV $(3/2^+)$. The spin assignment of $5/2^+$ to the 836 keV is not so certain. One would expect, in this region, the positive parity levels to be originating from the $g_{9/2}$ orbital. The $9/2^+$ state has not been located so far. In the present experiment also, there was no level which could be identified as having a $9/2^+$ character. In (p, n) reaction with a target of spin $3/2^-$, a $9/2^+$ is expected to be only weakly populated. However, in a similar situation, the $9/2^+$ level was populated in ^{75}Se and ^{81}Kr using ^{75}As(p, n)^{75}Se (Agarwal *et al* 1974) and ^{81}Br(p, n)^{81}Kr (Bharathi 1974) reactions. It is possible that the $9/2^+$ state in ^{79}Kr lies above an excitation energy of 600 keV. The $9/2^+$ level will lie higher in excitation energy if the nucleus has a deformation $\beta \simeq +0{\cdot}3$ (Chi 1966). This possibility cannot be ruled out.

The $7/2^+$ level at 130 keV seems to correspond to the $7/2^+$ level seen in the neighbouring odd neutron nuclei and such levels have already been discussed by Agarwal *et al* (1974). The occurrence of a low-lying $1/2^+$ level in ^{75}Se was considered by Agarwal *et al* (1974) to be an evidence for deformation in that nucleus. The situation here also seems to be similar and the 534 keV $(1/2^+)$ level could be understood as the (431 ↓) 1/2$^+$ Nilsson state. One may surmise that the 534, 695 and 835 keV levels form a rotational band. The observation of a 302 keV transition assigned from the 835 keV level to the 534 keV level on the basis of coincidence measurement supports this view. If such a rotational sequence is assumed, it yields a value of 41 keV for the moment of inertia parameter $\hbar^2/2\mathcal{J}$ and 0·31 for the decoupling parameter. The decoupling parameter calculated on the basis of Nilsson wave function for the (431 ↓) 1/2$^+$ orbital is very sensitive to the deformation parameter β_2 and varies from $+0{\cdot}5$ to $-1{\cdot}0$ for β_2 varying from $+0{\cdot}1$ to $+0{\cdot}3$ (Chi 1966).

From among the negative parity levels, a $K = \frac{1}{2}^-$ band has been identified with 0 ($\frac{1}{2}^-$), 183 (3/2$^-$), 291 (5/2$^-$) and the 720 (7/2$^-$) keV levels (Baba *et al* 1974). The parameters for this band are $\hbar^2/2\mathcal{J} = 41$ keV, $a = 0{\cdot}48$. As discussed earlier, the E2 component of the 183 keV transition is enhanced by a factor of more than 20 compared to the single particle estimate. If we assume an E2 enhancement factor of $\simeq$ 50 for this transition, the M1 component is retarded by a factor of $\simeq$ 20. One can expect this enhancement on the basis of the rotational model and this value of enhancement factor is also consistent with the above experimental limit. The 108 keV transition from the 291 keV (5/2$^-$) to 183 keV (3/2$^-$) level is also relatively very weak. From the measured relative intensities of the 291 keV and the 108 keV γ-rays, one could calculate a retardation factor of $\simeq$ 15 for the 108 keV M1 transition, if the 291 keV E2 transition is assumed to be enhanced by a factor $\simeq$ 50. It may be possible to understand the retardation of the M1 transition in terms of the magnetic properties of the band, *viz.*, $g_K - g_R$ and the decoupling parameter a. A similar $K = 1/2^-$ band has been identified in ^{75}Se and ^{77}Se (*see* Baba *et al* 1974) nuclei and this was further identified with the (301 ↓) 1/2$^-$ Nilsson orbit.

It is possible to identify the $K = 3/2^-$ rotational band with the levels at 384 (3/2$^-$), 660 (5/2$^-$) and 1038 (7/2$^-$) keV having inertial parameter $\hbar^2/2\mathcal{J} \simeq 55$ keV. Such a $K = 3/2^-$ band, identified with the (301 ↑) 3/2$^-$ Nilsson state, has also been

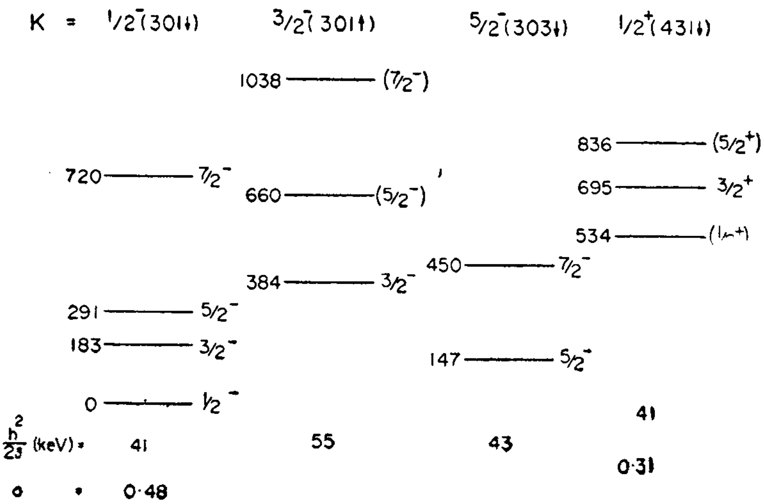

Figure 6. Partial level scheme of ^{79}Kr showing the four rotational bands proposed in the present work. The level energies are in keV.

found in ^{75}Se (Baba *et al* 1974). The difference in the moments of inertia can be understood on the basis of Coriolis coupling of these bands just like in the case of ^{75}Se (Baba *et al* 1974).

The $5/2^-$ level at 147 keV has characteristics similar to the $5/2^-$ level at 248 keV in ^{77}Se. One may be tempted to identify this as the band head of a $K = 5/2^-$ (303 $\downarrow$) band with 450 keV forming the $7/2^-$ member and having an inertial parameter $\hbar^2/2\mathcal{J} = 41$ keV. But no definite statement regarding such an assignment can be made on the basis of the existing data. All the proposed bands with $K = 1/2^+$. $1/2^-$, $3/2^-$ and a tentative band with $K = 5/2^-$ are shown in figure 6 with the corresponding parameters.

The levels discussed above exhaust most of the levels below $\simeq 800$ keV. Thus it seems possible to understand the low-lying levels in this region, especially the negative parity levels, on the basis of deformation. The situation with the positive parity levels is not so clear. It will be interesting to look for high spin states in nuclei in this region through other reactions in order to get further information on the rotational bands.

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