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Introduction to ENSDF Format and XUNDL Compilations

Nuclides, Isotopes, Isomers
All you wanted to know and learn
Just a few clicks away

Nuclide: 1947: Truman P. Kohman (Carnegie-Mellon Univ.) . Nucleus from nut of a fruit.

Atomic nucleus: 1912: E. Rutherford.

Isotope: 1913: Margaret Todd suggested word to radiochemist Frederick Soddy.

Isomer: from chemistry in 1831: J.J. Brezelius: ‘equal share’, but different properties.

- Atomic number: Z=0 to 118: free neutron (Z=0) to Og (Z=118).
- Neutron number: N=1 to N=177.
- Atomic weight: A=1 to 294
- ~3400 known nuclides (~300 naturally occurring, others produced in labs).
- Many new (and exotic) nuclides (in thousands) expected to be identified using new facilities: FRIB-MSU, FAIR-GSI, others…
- Need for detailed book-keeping of all the nuclear species and their characteristics was recognized long time ago, in a 1931 publication

M. Curie, A. Debierne, A.S. Eve, **H. Geiger**, **O. Hahn**, S.C. Lind, S. Meyer, **E. Rutherford**, E. Schweidle. S. Meyer from Univ. of Vienna, where, all records were kept.

The Radioactive Constants as of 1930: Report of the International Radium-Standards Commission. Reviews of Modern Physics **3**, 427 (1931).

Relevant structure and decay data

Ground states and long-lived isomers: Decay modes such as alpha, beta, gamma, particles, SF, …….; atomic masses.

Levels: half-lives, energies, spins and parities, magnetic dipole and electric quadrupole moments, ..

Gamma-transitions: energies, intensities, multipolarities, multipole mixing ratios for mixed multipolarities, internal conversion coefficients, ….

Radiations (alpha, beta, etc.): energies, intensities, other properties.

Experimental results extracted from ~65 K publications since the beginning of radioactivity (1896) and nuclear physics are contained in dedicated and unique databases, with above data types in certain computer formats.

IAEA-NDS

https://www-nds.iaea.org/

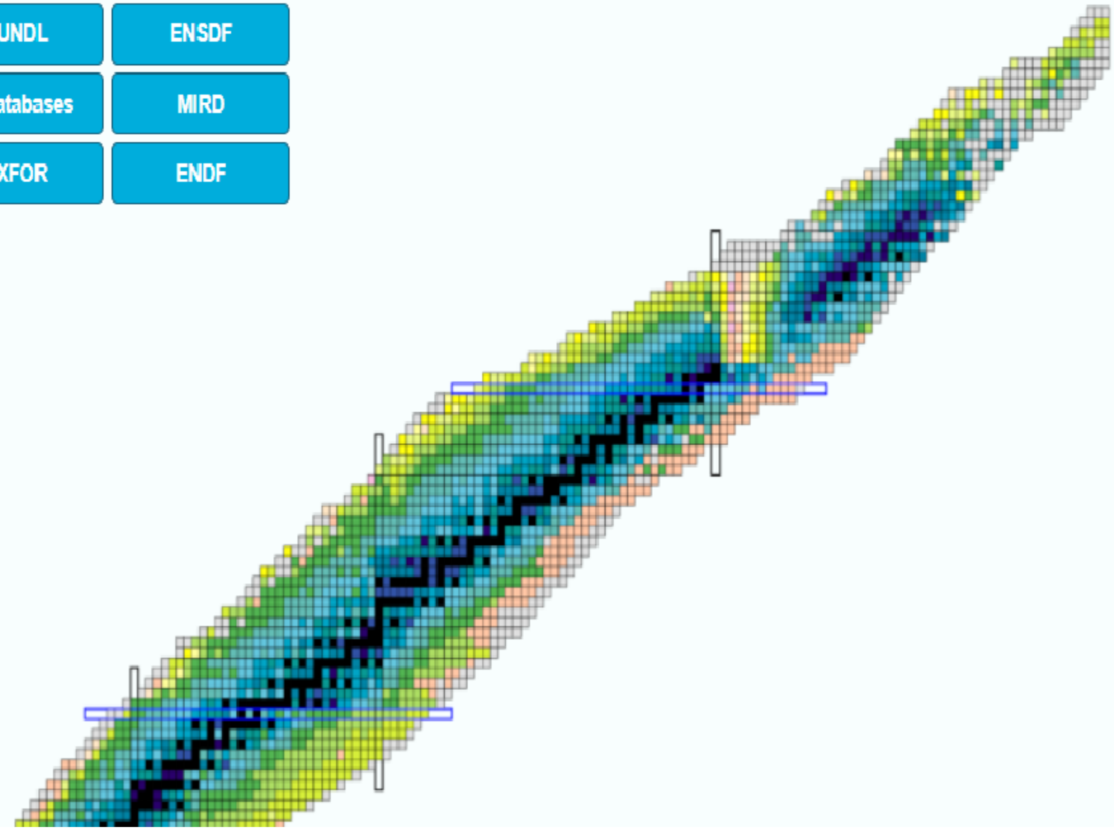
NNDC-Brookhaven National Lab, USA

www.nndc.bnl.gov

National Nuclear Data Center | Databases | Structure & Decay | Reactions

NSR	XUNDL	ENSDF
NuDat	Databases	MIRD
Sigma	EXFOR	ENDF

Chart of Nuclides



LNHB-Decay Data Evaluation Project
~250 nuclides of applied use

http://www.nucleide.org/DDEP_WG/DDEPdata.htm

Recommended data

New LNHB website

Le LNHB est heureux de vous présenter son nouveau site web.
(N'oubliez pas de mettre à jours vos liens.)

The LNHB is very pleased to present its new website.
(Do not forget to update your bookmarks.)

This introduction presents a brief description of the radioactivity physical processes, the enumeration of the evaluation rules leading to the recommended values, and a summary of the symbols and terms used in all the publications.

Explanation on recommended data and their evaluation (in various languages):

Tables of evaluated data and comments on evaluation
Pages updated by the Laboratoire National Henri Becquerel
All questions about the data must be sent to the authors. See chapter Addresses.

updated: **20th October 2017**
newly added: **Pr-142**
recently updated: **Sn-113**
ASCII files updated on: **24/06/2016**
(**221** nuclides in table, sorted by **alphabetical order** / atomic number / mass number / edition date)

(History of older evaluations, sorted by **alphabetical order**)

Please cite our evaluations using the following references:

Vol.	Publication	Year	ISBN	NSR	BibTeX
99	CEA Report - Table de Radionucléides	1999	2-7272-0200-8	1999BeZQ	TabRad_v0.bib
1	Monographie BIPM-5 - Table of Radionuclides, vol. 1	2004	92-822-2206-3	2004BeZR	TabRad_v1.bib
2	Monographie BIPM-5 - Table of Radionuclides, vol. 2	2004	92-822-2207-1	2004BeZQ	TabRad_v2.bib
3	Monographie BIPM-5 - Table of Radionuclides, vol. 3	2006	92-822-2218-7	2006BeZL	TabRad_v3.bib
4	Monographie BIPM-5 - Table of Radionuclides, vol. 4	2008	92-822-2231-4	2008BeZV	TabRad_v4.bib
5	Monographie BIPM-5 - Table of Radionuclides, vol. 5	2010	978-92-822-2234-8	2010BeZQ	TabRad_v5.bib
6	Monographie BIPM-5 - Table of Radionuclides, vol. 6	2011	978-92-822-2242-3	2011BeZW	TabRad_v6.bib
7	Monographie BIPM-5 - Table of Radionuclides, vol. 7	2013	978-92-822-2248-5	2013BeZP	TabRad_v7.bib
8	Monographie BIPM-5 - Table of Radionuclides, vol. 8	2016	978-92-822-2264-5	2016BeZX	TabRad_v8.bib

Subscribe to DDEP RSS feed

(*Type of updates: **N** - new evaluation; **1** - update in comments only; **2** - minor update in table; **3** - major update in table)

Nuclide		Tables	Comments	ASCII files			Vol.	UpDate	Type*
				ENSDF	PenNuc	Lara			
Ac-225	^{225}Ac	table	comments	ensdf	pennuc	txt	5	26/08/2009	3
Ac-227	^{227}Ac	table	comments	ensdf	pennuc	txt	4	16/02/2009	2
Ac-228	^{228}Ac	table	comments	ensdf	pennuc	txt	6	22/01/2010	3
Ag-108	^{108}Ag	table	comments	ensdf	pennuc	txt	3	4/09/2006	2
Ag-108m	^{108m}Ag	table	comments	ensdf	pennuc	txt	3	17/01/2012	2
Ag-110	^{110}Ag	table	comments	ensdf	pennuc	txt	1	12/03/2004	1
Ag-110m	^{110m}Ag	table	comments	ensdf	pennuc	txt	1	24/03/2004	1
Al-26	^{26}Al	table	comments	ensdf	pennuc	txt	99	24/07/2003	1
Am-241	^{241}Am	table	comments	ensdf	pennuc	txt	5	20/08/2010	2
Am-242	^{242}Am	table	comments	ensdf	pennuc	txt	5	18/01/2011	2
Am-242m	^{242m}Am	table	comments	ensdf	pennuc	txt	6	18/01/2011	2
Am-243	^{243}Am	table	comments	ensdf	pennuc	txt	5	26/02/2010	2
Am-244	^{244}Am	table	comments	ensdf	pennuc	txt	5	18/01/2011	2

Nuclide		Table
O-15	^{15}O	table
P-32	^{32}P	table
P-33	^{33}P	table
Pa-231	^{231}Pa	table
Pa-233	^{233}Pa	table
Pa-234	^{234}Pa	table
Pa-234m	^{234m}Pa	table
Pb-203	^{203}Pb	table
Pb-209	^{209}Pb	table
Pb-210	^{210}Pb	table
Pb-211	^{211}Pb	table
Pb-212	^{212}Pb	table

ENSDF database

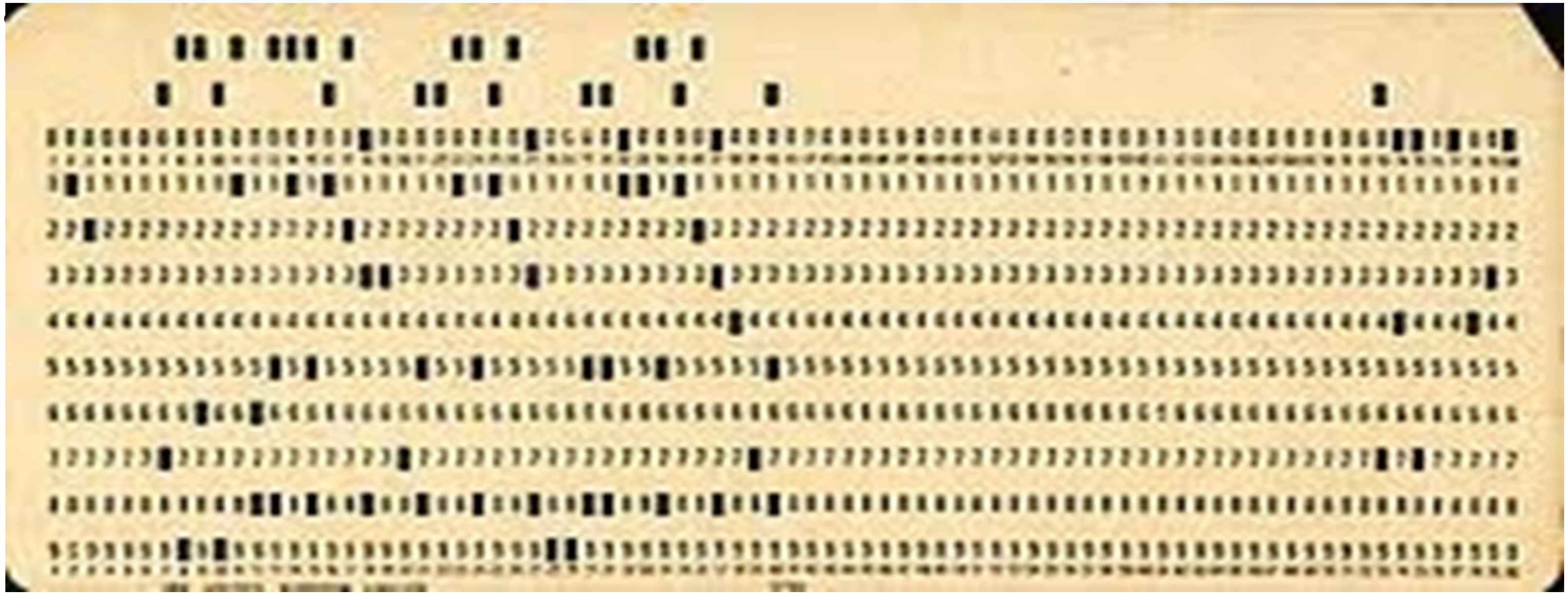
- ENSDF: Evaluated Nuclear Structure Data File: 1978 – present.

- Structure and decay data for all the known nuclides, although, for many nuclides, data in current ENSDF are much outdated: examples:
  Nuclides of A=76 (Dec 1994); A=118 (Nov 1992), 130 (May 2001).

- To partially fill the gap, a project of compilation of nuclear structure data from more recent papers was started at McMaster University in Canada by me in 1998. Semi-automatic procedures were developed to convert extensive data tables in .pdf (e.g. in high-spin physics) to **.ensdf computer format**. Most of the initial comilation work was done by (A^+, A) undergraduate students in B.Sc. Hons. (Physics) after their first and second year of studies. Between 1998-2019, about 20 students participated in this project. At an IAEA meeting in Dec 1998, the database was called: **eXperimental Nuclear Data List (XUNDL).**

ENSDF data entry format

- 1977: ENSDF format of entering data for levels and transitions was developed at Oak Ridge National Laboratory by Drs. Bruce Ewbank and Marcel Schmorak, around IBM’s 80-column, 12-rows punched-card image, which had been around since 1928. Letters, numbers, symbols on a typewriter in Octal format. Card-punch machines and readers: until 1981.



ENSDF format: bird's eye-view of a total of 16 record types.
For the gamma-ray data only, you need just 4 record types:
DS-ID record, PN record for drawing, Level record (L), Gamma record (G)

ENSDF Standard 80-character Formated Records

Record																			
IDENT	NUCID	&	blank	DSID	DSREF	PUB	DATE												
XREF	NUCID	blank	X	!	DSID	blank													
REF	AAA	blank	R	bl	KEYNUMBER	REFERENCE													
HIST	NUCID	&	bl	H	bl	HTEXT													
Q-VALUE	NUCID	blank	Q	bl	Q-	DQ-	SN	DSN	SP	DSP	QA	DQA	QREF						
G COMM	NUCID	&	†	#	bl	CTEXT													
F/R COMM	NUCID	&	†	#	‡	SYM(FLAG)	CTEXT												
PARENT	NUCID	blank	P	š	E	DE	J	T	DT	blank	QP	DQP	ION						
NORM	NUCID	blank	N	š	NR	DNR	NT	DNT	BR	DBR	NB	DNB	NP	DNP	blank				
P NORM	NUCID	&	P	N	š	NR*BR	UNC	NT*BR	UNC	blank	NB*BR	UNC	NP	DNP	blank				
LEVEL	NUCID	&	bl	L	bl	E	DE	J	T	DT	L	S	DS	F	MS	Q			
BETA	NUCID	&	bl	B	bl	E	DE	IB	DIB	blank	LOGFT	DFT	blank	F	UN	Q			
EC	NUCID	&	bl	E	bl	E	DE	IB	DIB	IE	DIE	LOGFT	DFT	blank	F	UN	Q		
ALPHA	NUCID	&	bl	A	bl	E	DE	IA	DIA	HF	DHF	blank	F	bl	Q				
PART	NUCID	&	bl	¶	E	DE	IP	DIP	ED	T	DT	L	blank	F	C	bl	Q		
GAMMA	NUCID	&	bl	G	bl	E	DE	RI	DRI	M	MR	DMR	CC	DCC	TI	DTI	F	C	bl	Q

ENSDF format: text editing
Use a text editor: example: TEXTPAD: free software

Data input:

All energies in **keV.**

Columns 1-3: mass number, right justified; 149; -98

Columns 4-5: Element name: left justified;   SM; Y-.

Examples: 149SM; -98Y-

First record: Data set ID: columns 10-39: reaction: **40CA(28SI,APG).** Columns 40-56: optional: Reference: NSR key-number: 2021SH09

Second to --- records: optional Header records as general comments about the dataset: column 7: c. Column 6: numerals 2 to n, for continuation of record comments, after the first one.

Specific comments: cL BAND(A)$ |p 5/2[303] band

PN record: columns 7-8: PN. Column 78: 5 for relative gamma-intensities; 6 for relative gamma-branching ratios; 7 for absolute gamma-branching ratios

ENSDF format: Level record

Level record:

Column 8: character L

Columns 10-19: level energy

Columns 20-21: uncertainty in energy.

Columns 40-49: level half-life (space) units (FS, PS, NS, US, MS, S, M, H, D, Y) Columns 50-55: uncertainty in half-life, accommodates asymmetric uncertainty.

Examples: 22.4 PS 10 for half-life of 22.4(10) ps. 22.4 PS +10-15 for 22.4(+10-15) ps.

Column 77: character for band label, such as A, B, C, …

Columns 78-79: labeling an isomer: M in column 78, numerals 1-n, if more than one isomer.

Column 80: ? If a level is uncertain, for example, dotted in level scheme

ENSDF format: Gamma record

Column 8: character G

Columns 10-19: Gamma energy (in keV)

Columns 20-21: uncertainty in energy.

Columns 22-29: Gamma intensity

Columns 30-31: uncertainty in gamma intensity

Columns 32-41: multipolarity, examples: E2, (E2), [E2], M1, M1+E2, Q, D, D+Q, etc.

Columns 42-49: mixing ratio

Columns 50-55: uncertainty in mixing ratio

Columns 56-62: internal conversion coefficient (ICC): theory from BrIcc

Columns 63-64: uncertainty in ICC (optional: 1.4% assumed by default)

Column 80: ? If gamma placement is uncertain, for example, dotted in level scheme.

ENSDF format: example: ^{87}Br
2021Ny01: PRC 103, 034301 (2021): first high-spin study

Starting with the ground state as level record with energy 0.0, enter each level energy record followed by gamma record(s), the latter in increasing order.

Final record: blank

TABLE I. Level energies, spin-parities, γ-ray energies and relative intensities, as well as γ-ray branching ratios corresponding to the observed medium-spin level scheme of ^{87}Br. The relative intensities are normalized to that of the strong 662.9 keV transition. "nb" denotes a level not belonging to any band.

E_i	I_i^{π}	Band	E_f	E_γ	I_γ	BR
0.0	$5/2^-$	1				
6.0(3)	$3/2^-$	2				
332.9(4)	$(3/2^-)$	nb	0.0	333.1(6)	>2	
578.8(2)	$(5/2^-)$	2	0.0	578.7(3)	>7	42(9)
			6.0	572.8(3)	>17	100(9)
			332.9	246.0(5)	>2	12(4)
618.7(3)	$(7/2^-)$	1	0.0	618.9(4)	>26	
801.5(2)	$7/2^-$	2	0.0	801.4(3)	46(5)	
			6.0	795.5(3)	54(5)	
			578.8	222.7(3)	26(4)	
875.3(3)	$9/2^-$	1	0.0	875.2(5)	>45	100(17)
			618.7	257.0(7)	>5	12(3)
1464.4(3)	$9/2^+$	3	618.7	845.7(6)	15(3)	
			801.5	662.9(2)	100(8)	
			875.3	589.1(3)	31(3)	
1561.4(5)	$(11/2^-)$	1	618.7	942.7(5)	>4	
1917.4(6)	$(13/2^-)$	1	875.3	1042.0(6)	19(3)	
			1561.4	356.0(7)	4(2)	
2226.3(3)	$13/2^+$	3	1464.4	761.9(2)	77(6)	
3098.0(4)	$17/2^+$	3	2226.3	871.7(2)	31(4)	
4094.0(5)	$(21/2^+)$	3	3098.0	996.0(3)	12(2)	
5199.2(6)	$(25/2^+)$	3	4094.0	1105.2(3)	7(2)	

2021Ny01: 87Br example

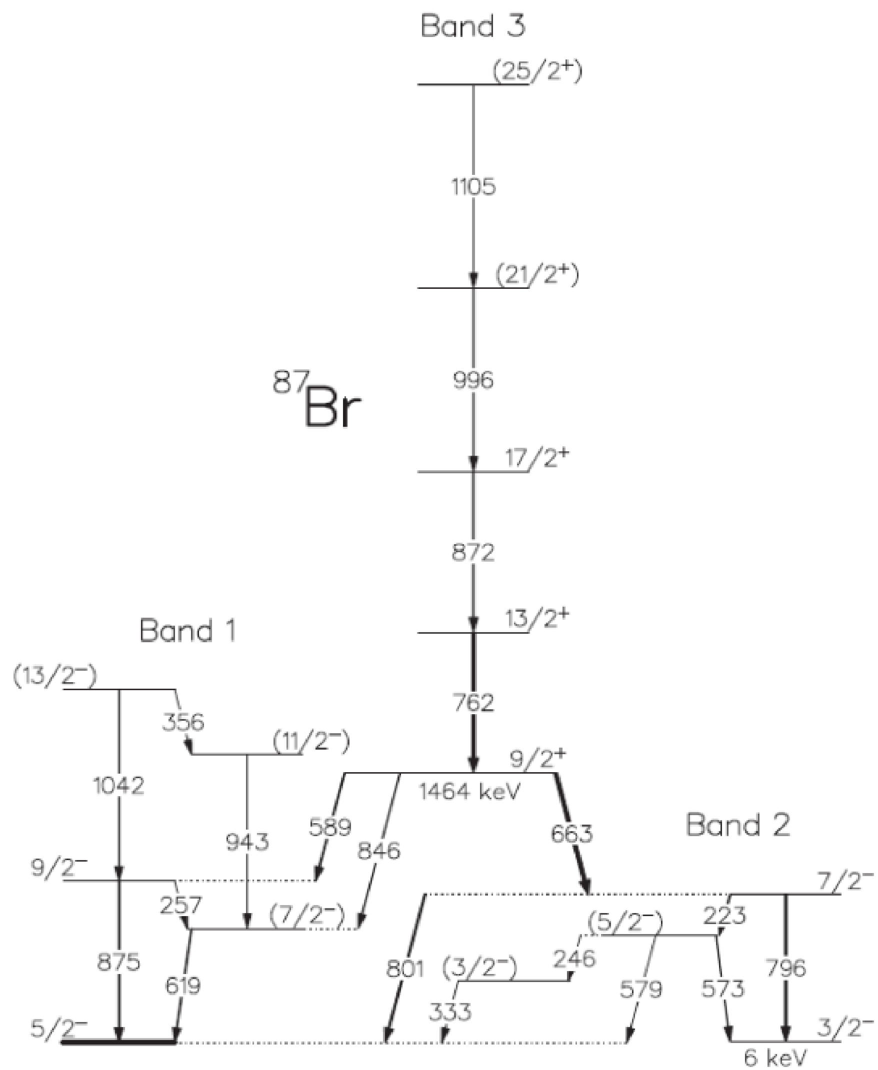


FIG. 2. Partial level scheme of ^{87}Br, seen in prompt coincidence with ^{146}La and ^{147}La. The energies are given in keV, the widths of the

Example: ^{87}Br

```
87BR    235U(N,FG)                  2021NYAA                      202103
87BR c  Compiled dataset from 2021NyAA: B.M. Nyako et al.,
87BR2c  Phys. Rev. C 103, 034304 (March 3, 2021)
87BR c  2021NyAA: E(n)=cold neutrons from ILL-Grenoble. Measured E|g, I|g,
87BR2c  |g|g-coin, |g|g(|q) using EXILL HPGe detector array of eight
87BR3c  Compton-suppressed EXOGAM clover detectors, six Compton-suppressed
87BR4c  GASP detectors, and two Clover detectors of the Lohengrin spectrometer.
87BR5c  Deduced high-spin levels, J|p, bands, and configurations. Comparison
87BR6c  with shell-model calculations.
87BR c  First high-spin study of {+87}Br  (optional)
87BR cL BAND(A)$ |p5/2[303], f{-5/2}
87BR cL BAND(B)$ |p3/2[301], p{-3/2}+f{-5/2}
87BR cL BAND(C)$ |p1/2[440], g{-9/2}
87BR PN                                                              5
```

ENSDF-format: data

```
87BR  L 0.0          5/2-                                       A
87BR  L 6.0       3  3/2-                                       B
87BR  L 332.9     4  (3/2-)
87BR  G 333.1     6  2      GT
87BR  L 578.8     2  (5/2-)                                     B
87BR  G 246.0     5  2      GT
87BR cG $I|g(246)/I|g(573)=12 {I4}/100 {I9}
87BR  G 572.8     3  17     GT
87BR cG $I|g(579)/I|g(573)=42 {I9}/100 {I9}
87BR  G 578.7     3  7      GT
87BR  L 618.7     3  (7/2-)                                     A
87BR  G 618.9     4  26     GT
87BR  L 801.5     2   7/2-                                      B
87BR  G 222.7     3  26     4
87BR  G 795.5     3  54     5  Q
87BR cG M$stretched quadrupole from |g|g(|q)
87BR  G 801.4     3  46     5
87BR  L 875.3     3  9/2-                                       A
87BR  G 257.0     7  5      GT
87BR cG $I|g(257)/I|g(875)=12 {I3}/100 {I17}
87BR  G 875.2     5  45     GT  Q
87BR cG M$stretched quadrupole from |g|g(|q)
```

Data: contd.

```
87BR  L 1464.4    3   9/2+                                    C
87BR  G 589.1     3  31     3  D+Q       -0.456
87BR cG $|DJ=0 transition. The |g|g(|q) data not consistent with stretched
87BR2cG dipole for 589.1|g, with stretched quadrupole for 875.2|g
87BR cG $(589.1|g)(875.2|g)(|q): A{-2}=+0.24 {I2}, A{-4}=+0.08 {I4}
87BR  G 662.9     2  100    8  D
87BR cG $(662.9|g)(795.5|g)(|q): A{-2}=-0.05 {I4}, A{-4}=+0.05 {I10}
87BR cG M$stretched dipole from |g|g(|q)
87BR  G 845.7     6  15     3
87BR  L 1561.4    5   (11/2-)                                 A
87BR  G 942.7     5  4      GT
87BR  L 1917.4    6   (13/2-)                                 A
87BR  G 356.0     7   4     2
87BR  G 1042.0    6  19     3
87BR  L 2226.3    3   13/2+                                   C
87BR  G 761.9     2  77     6  Q
87BRcG M$stretched quadrupole from |g|g(|q)
87BR  L 3098.0    4   17/2+                                   C
87BR  G 871.7     2  31     4  Q
87BRcG $(871.7|g)(761.9|g)(|q): A{-2}=+0.11 {I6}, A{-4}=-0.09 {I13}
87BRcG M$stretched quadrupole from |g|g(|q)
87BR  L 4094.0    5   (21/2+)                                 C
87BR  G 996.0     3  12     2
87BR  L 5199.2    6   (25/2+)                                 C
87BR  G 1105.2    3  7      2
```

NDS-style output using McMaster-MSU JAVA-NDS code

^{235}U(n,Fγ) 2021NyAA

Compiled dataset from 2021NyAA: B.M. Nyako et al., Phys. Rev. C 103, 034304 (March 3, 2021).

2021NyAA: E(n)=cold neutrons from ILL-Grenoble. Measured Eγ, Iγ, $\gamma\gamma$-coin, $\gamma\gamma(\theta)$ using EXILL HPGe detector array of eight Compton-suppressed EXOGAM clover detectors, six Compton-suppressed GASP detectors, and two Clover detectors of the Lohengrin spectrometer. Deduced high-spin levels, Jπ, bands, and configurations. Comparison with shell-model calculations.

First high-spin study of ^{87}Br.

^{87}Br Levels

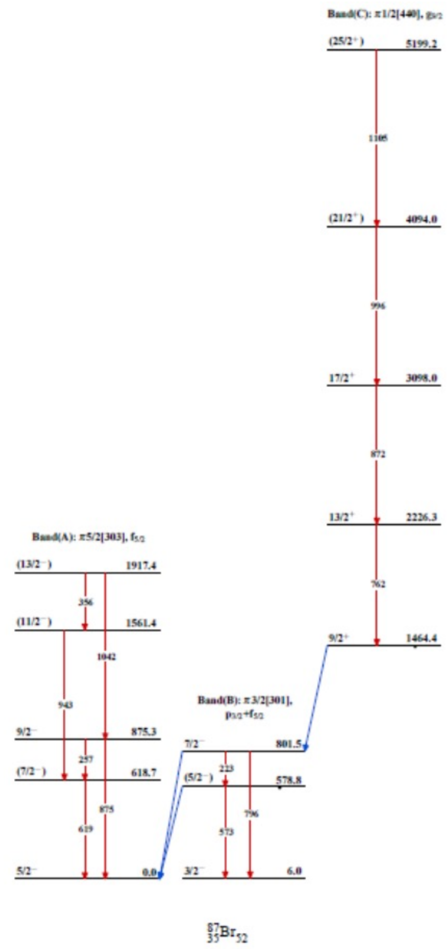
E(level)	J^π	E(level)	J^π	E(level)	J^π	E(level)	J^π
0.0†	$5/2^-$	618.7† *3*	$(7/2^-)$	1561.4† *5*	$(11/2^-)$	4094.0# *5*	$(21/2^+)$
6.0‡ *3*	$3/2^-$	801.5‡ *2*	$7/2^-$	1917.4† *6*	$(13/2^-)$	5199.2# *6*	$(25/2^+)$
332.9 *4*	$(3/2^-)$	875.3† *3*	$9/2^-$	2226.3# *3*	$13/2^+$		
578.8‡ *2*	$(5/2^-)$	1464.4# *3*	$9/2^+$	3098.0# *4*	$17/2^+$		

† Band(A): π5/2[303], $f_{5/2}$.
‡ Band(B): π3/2[301], $p_{3/2}+f_{5/2}$.
# Band(C): π1/2[440], $g_{9/2}$.

γ(^{87}Br)

E_γ	I_γ	E_i(level)	J_i^π	E_f	J_f^π	Mult.	δ	Comments
222.7 *3*	26 *4*	801.5	$7/2^-$	578.8	$(5/2^-)$			
246.0 *5*	>2	578.8	$(5/2^-)$	332.9	$(3/2^-)$			Iγ(246)/Iγ(573)=12 *4*/100 *9*.
257.0 *7*	>5	875.3	$9/2^-$	618.7	$(7/2^-)$			Iγ(257)/Iγ(875)=12 *3*/100 *17*.
333.1 *6*	>2	332.9	$(3/2^-)$	0.0	$5/2^-$			
356.0 *7*	4 *2*	1917.4	$(13/2^-)$	1561.4	$(11/2^-)$			
572.8 *3*	>17	578.8	$(5/2^-)$	6.0	$3/2^-$			Iγ(579)/Iγ(573)=42 *9*/100 *9*.
578.7 *3*	>7	578.8	$(5/2^-)$	0.0	$5/2^-$			
589.1 *3*	31 *3*	1464.4	$9/2^+$	875.3	$9/2^-$	D+Q	−0.456	ΔJ=0 transition. The $\gamma\gamma(\theta)$ data not consistent with stretched dipole for 589.1γ, with stretched quadrupole for 875.2γ. (589.1γ)(875.2γ)(θ): A_2=+0.24 *2*, A_4=+0.08 *4*.
618.9 *4*	>26	618.7	$(7/2^-)$	0.0	$5/2^-$			
662.9 *2*	100 *8*	1464.4	$9/2^+$	801.5	$7/2^-$	D		(662.9γ)(795.5γ)(θ): A_2=−0.05 *4*, A_4=+0.05 *10*. Mult.: stretched dipole from $\gamma\gamma(\theta)$.
761.9 *2*	77 *6*	2226.3	$13/2^+$	1464.4	$9/2^+$	Q		Mult.: stretched quadrupole from $\gamma\gamma(\theta)$.
795.5 *3*	54 *5*	801.5	$7/2^-$	6.0	$3/2^-$	Q		Mult.: stretched quadrupole from $\gamma\gamma(\theta)$.
801.4 *3*	46 *5*	801.5	$7/2^-$	0.0	$5/2^-$			
845.7 *6*	15 *3*	1464.4	$9/2^+$	618.7	$(7/2^-)$			
871.7 *2*	31 *4*	3098.0	$17/2^+$	2226.3	$13/2^+$	Q		(871.7γ)(761.9γ)(θ): A_2=+0.11 *6*, A_4=−0.09 *13*. Mult.: stretched quadrupole from $\gamma\gamma(\theta)$.
875.2 *5*	>45	875.3	$9/2^-$	0.0	$5/2^-$	Q		Mult.: stretched quadrupole from $\gamma\gamma(\theta)$.
942.7 *5*	>4	1561.4	$(11/2^-)$	618.7	$(7/2^-)$			
996.0 *3*	12 *2*	4094.0	$(21/2^+)$	3098.0	$17/2^+$			
1042.0 *6*	19 *3*	1917.4	$(13/2^-)$	875.3	$9/2^-$			
1105.2 *3*	7 *2*	5199.2	$(25/2^+)$	4094.0	$(21/2^+)$			

Band drawing from JAVA-NDS code



Checking consistency of data in a paper through a suite of ENSDF computer codes

- FMTCHK (Fortran): check data formatting.
- GTOL (Fortran) or GLSC (JAVA): least-squares fitting of Eg values to obtain level energies.
- PANDORA (Fortran) or ENSDF-consistency check (JAVA): physics check and analysis of a level scheme.
- BrIcc (Fortran): theoretical internal conversion coefficients if multipolarities (and multipole mixing ratios) are known.
- Use of all the codes will be discussed during the workshop.

XUNDL compilations: exercises

2022Mu09: 81Kr: PL-B 827, 137005 (2022): high-spin study

Multiple chiral-doublet bands (previous study: 1986Su03: NP-A 455, 206).

[Requested data details August 29, 2022 from authors: no response yet].

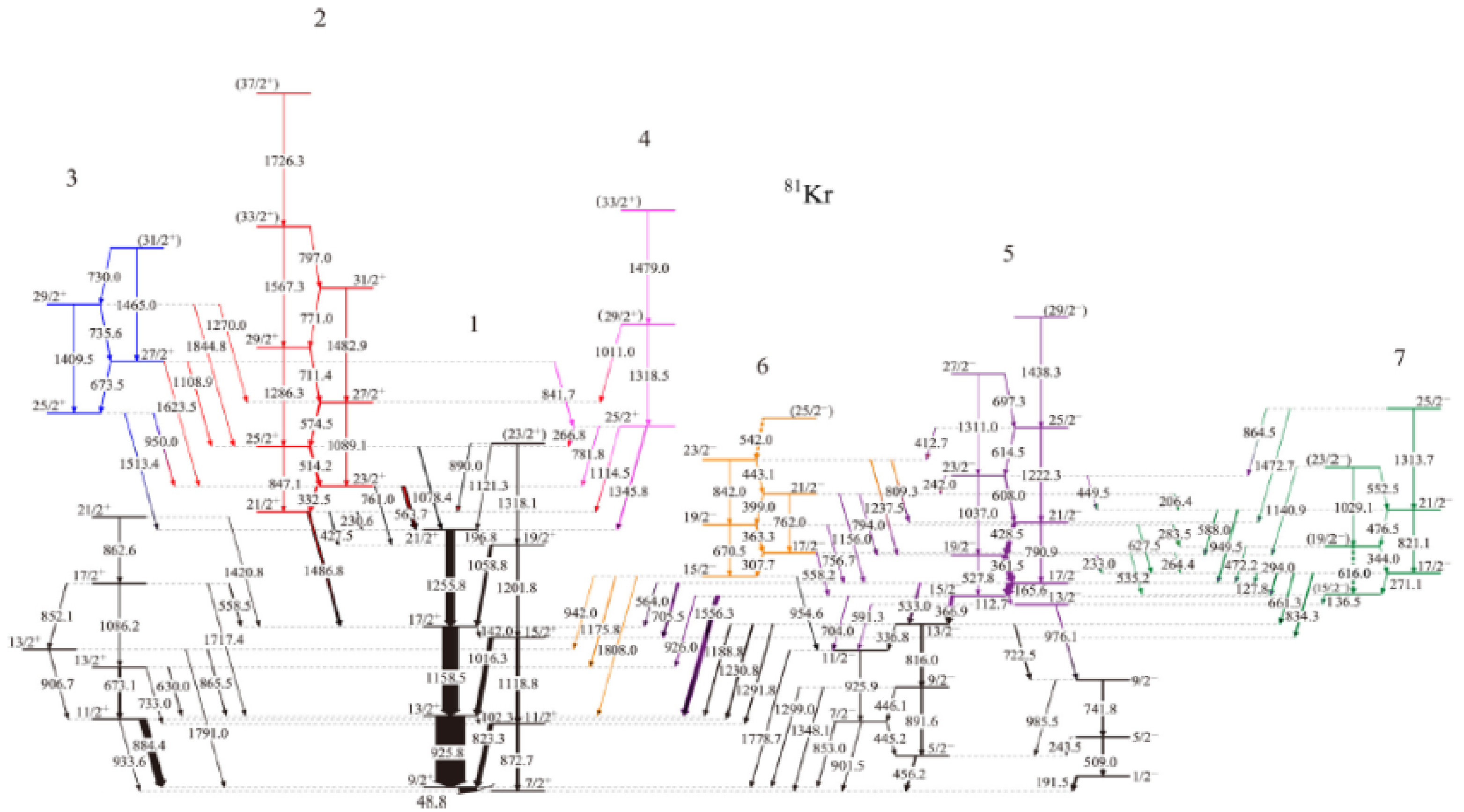


Fig. 1. Level scheme of ^{81}Kr derived from the present work. The energies are given in keV, and the widths of the arrows are proportional to the relative transition intensities. Levels and intraband transitions are colored in group by bands. The ends of linking transitions are colored by their initial states while the tips are colored by their final states.

81Kr: XUNDL: compiled from level scheme

- 81KR   82SE(A,5NG):XUNDL   2022MU09   202210
- 81KR c 2022Mu09: Phys. Lett. B827, 137006 (20222).
- 81KR c Gamma-ray data details such as relative intensities, numerical values
- 81KR2c of |g|g(|q)(ADO) requested by B. Singh from the corresponding author
- 81KR3c August 29, 2022; and again sent email Sept 30, 2022, but no response
- 81KR4c as of October 03, 2022.
- 81KR cL E$Deduced by compiler from least-squares fit to E|g data, assuming
- 81KR2cL 0.5 keV uncertainty for each E|g value.
- 81KR cL BAND(A)$Band #1, based on 9/2+ |a=+1/2
- 81KR cL BAND(a)$Band #1, based on 7/2+, |a=-1/2
- 81KR cL BAND(B)$Band #2, based on 21/2+, |a=+1/2
- 81KR cL BAND(b)$Band #2, based on 23/2+, |a=-1/2
- 81KR cL BAND(C)$Band #3, based on 25/2+, 4908
- 81KR cL BAND(D)$Band #4, based on 25/2+, 4780
- 81KR cL BAND(E)$Band #5, based on 13/2-, |a=+1/2
- 81KR cL BAND(e)$Band #5, based on 15/2-, |a=-1/2
- 81KR cL BAND(F)$Band #6, based on 17/2-, |a=+1/2
- 81KR cL BAND(f)$Band #6, based on 15/2-, |a=-1/2
- 81KR cL BAND(G)$Band #7, based on 17/2-, |a=+1/2
- 81KR cL BAND(g)$Band #7, based on (15/2-), |a=-1/2
- 81KR cL BAND(H)$Band based on 1/2-
- 81KR cL BAND(I)$Band based on 5/2-
- 81KR cL BAND(J)$Band based on 11/2+
-

81Kr: compiled dataset

- 81KR L 0.0 7/2+ a
- 81KR L 49.0 3 9/2+ A
- 81KR G 48.8
- 81KR L 191.3 4 1/2- H
- 81KR G 191.5
- 81KR L 456.4 3 5/2- I
- 81KR G 456.2
- 81KR L 700.1 4 5/2- H
- 81KR G 243.5
- 81KR G 509.0
- 81KR L 872.6 3 11/2+ a
- 81KR G 823.3
- 81KR G 872.7
- 81KR L 901.7 3 7/2- I
- 81KR G 445.2
- 81KR G 853.0
- 81KR G 901.5
- 81KR L 933.3 3 11/2+ J
- 81KR G 884.4
- 81KR G 933.6
- 81KR L 975.0 3 13/2+ A
- 81KR G 102.3
- 81KR G 925.8
- 81KR L 1348.0 3 9/2- I
- ....contd. Total: 239 lines of data.

NDS-style output

2022Mu09: Phys. Lett. B827, 137006 (20222).
Gamma-ray data details such as relative intensities, numerical values of $\gamma\gamma(\theta)$(ADO) requested by B. Singh from t corresponding author August 29, 2022; and again sent email Sept 30, 2022, but no response as of October 01.
Compiled by B. Singh (McMaster), October 01, 2022.

^{81}Kr Levels

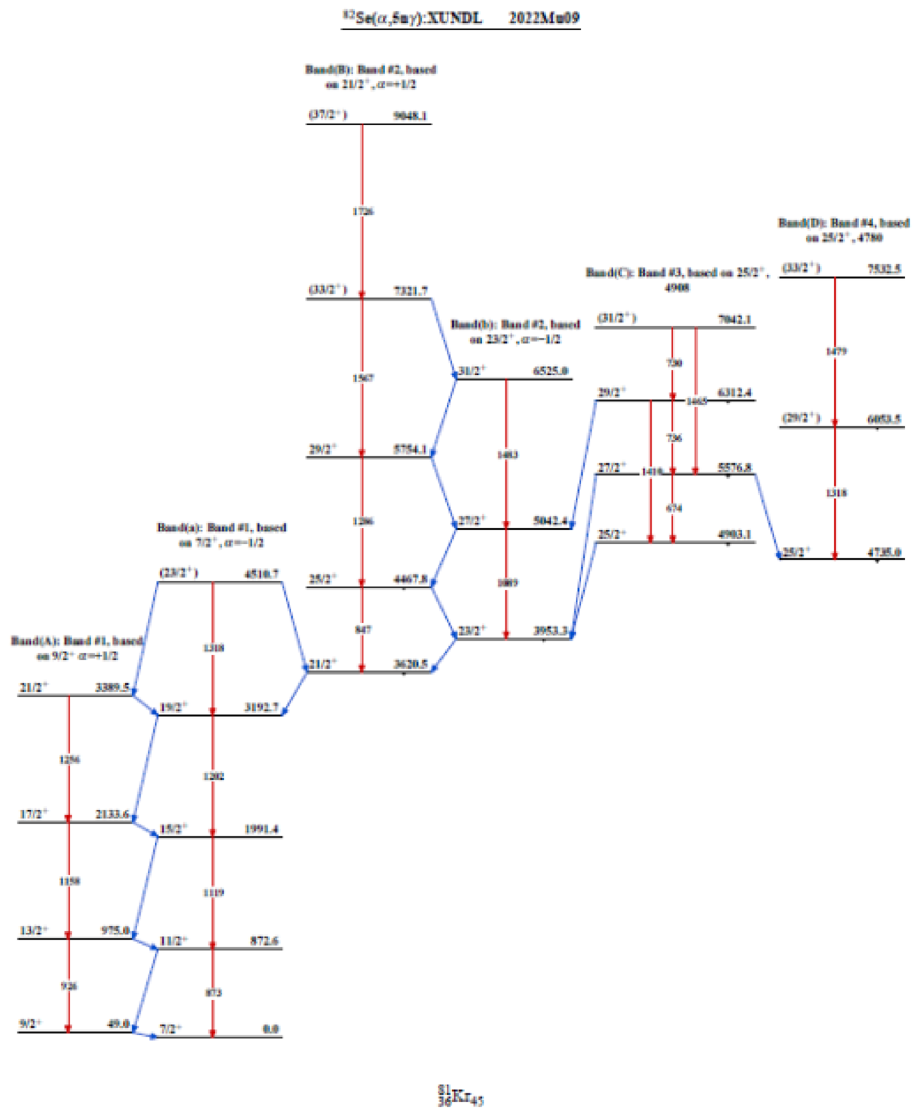
E(level)[†]	J^π	E(level)[†]	J^π	E(level)[†]	J^π	E(level)[†]	J^π
0.0[#]	$7/2^+$	2133.6[‡] 4	$17/2^+$	3487.1[c] 4	$21/2^-$	4959.9[g] 5	$25/2^-$
49.0[‡] 3	$9/2^+$	2164.2[j] 3	$13/2^-$	3554.6[k] 5	$21/2^+$	5042.4[&] 6	$27/2^+$
191.3[i] 4	$1/2^-$	2418.6[c] 4	$13/2^-$	3620.5[@] 5	$21/2^+$	5406.4[d] 6	$27/2^-$
456.4[j] 3	$5/2^-$	2531.4[d] 4	$15/2^-$	3646.4[g] 4	$21/2^-$	5576.8[a] 6	$27/2^+$
700.1[i] 4	$5/2^-$	2554.6[h] 4	$(15/2^+)$	3852.8[e] 4	$21/2^-$	5754.1[@] 6	$29/2^+$
872.6[#] 3	$11/2^+$	2692.2[k] 4	$17/2^+$	3953.3[&] 5	$23/2^+$	6053.5[b] 6	$(29/2^+)$
901.7[j] 3	$7/2^-$	2697.2[c] 4	$17/2^-$	4095.3[d] 4	$23/2^-$	6147.6[c] 7	$(29/2^-)$
933.3[k] 3	$11/2^+$	2782.4[f] 4	$15/2^-$	4199.2[h] 5	$(23/2^-)$	6312.4[a] 6	$29/2^+$
975.0[‡] 3	$13/2^+$	2825.6[g] 4	$17/2^-$	4296.1[f] 4	$23/2^-$	6525.0[&] 7	$31/2^+$
1348.0[j] 3	$9/2^-$	3058.6[d] 4	$19/2^-$	4467.8[@] 5	$25/2^+$	7042.1[a] 7	$(31/2^+)$
1441.9[i] 4	$9/2^-$	3090.1[e] 4	$17/2^-$	4510.7[#] 6	$(23/2^+)$	7321.7[@] 7	$(33/2^+)$
1605.8[k] 4	$13/2^+$	3169.9[h] 4	$(19/2^-)$	4709.3[c] 5	$25/2^-$	7532.5[b] 8	$(33/2^+)$
1827.5[j] 4	$11/2^-$	3192.7[#] 5	$19/2^+$	4735.0[b] 5	$25/2^+$	9048.1[@] 9	$(37/2^+)$
1840.2 4	$13/2^+$	3389.5[‡] 5	$21/2^+$	4838.1[e] 7	$(25/2^-)$		
1991.4[#] 4	$15/2^+$	3453.5[f] 4	$19/2^-$	4903.1[a] 6	$25/2^+$		

[†] Deduced by compiler from least-squares fit to Eγ data, assuming 0.5 keV uncertainty for each Eγ value.
[‡] Band(A): Band #1, based on $9/2^+$ α=+1/2.
[#] Band(a): Band #1, based on $7/2^+$, α=−1/2.
[@] Band(B): Band #2, based on $21/2^+$, α=+1/2.
[&] Band(b): Band #2, based on $23/2^+$, α=−1/2.
[a] Band(C): Band #3, based on $25/2^+$, 4908.
[b] Band(D): Band #4, based on $25/2^+$, 4780.
[c] Band(E): Band #5, based on $13/2^-$, α=+1/2.
[d] Band(e): Band #5, based on $15/2^-$, α=−1/2.
[e] Band(F): Band #6, based on $17/2^-$, α=+1/2.
[f] Band(f): Band #6, based on $15/2^-$, α=−1/2.
[g] Band(G): Band #7, based on $17/2^-$, α=+1/2.
[h] Band(g): Band #7, based on $(15/2^-)$, α=−1/2.
[i] Band(H): Band based on $1/2^-$.
[j] Band(I): Band based on $5/2^-$.
[k] Band(J): Band based on $11/2^+$.

γ(^{81}Kr) (continued)

E_γ	E_i(level)	J_i^π	E_f	J_f^π
242.0	4095.3	$23/2^-$	3852.8	$21/2^-$
243.5	700.1	$5/2^-$	456.4	$5/2^-$
264.4	3090.1	$17/2^-$	2825.6	$17/2^-$
266.8	4735.0	$25/2^+$	4467.8	$25/2^+$
271.1	2825.6	$17/2^-$	2554.6	$(15/2^+)$
283.5	3453.5	$19/2^-$	3169.9	$(19/2^-)$
294.0	2825.6	$17/2^-$	2531.4	$15/2^-$
307.7	3090.1	$17/2^-$	2782.4	$15/2^-$
332.5	3953.3	$23/2^+$	3620.5	$21/2^+$
336.8	2164.2	$13/2^-$	1827.5	$11/2^-$
344.0	3169.9	$(19/2^-)$	2825.6	$17/2^-$
361.5	3058.6	$19/2^-$	2697.2	$17/2^-$
363.3	3453.5	$19/2^-$	3090.1	$17/2^-$
366.9	2531.4	$15/2^-$	2164.2	$13/2^-$
399.0	3852.8	$21/2^-$	3453.5	$19/2^-$
412.7	4709.3	$25/2^-$	4296.1	$23/2^-$
427.5	3620.5	$21/2^+$	3192.7	$19/2^+$
428.5	3487.1	$21/2^-$	3058.6	$19/2^-$
443.1	4296.1	$23/2^-$	3852.8	$21/2^-$
445.2	901.7	$7/2^-$	456.4	$5/2^-$
446.1	1348.0	$9/2^-$	901.7	$7/2^-$
449.5	4095.3	$23/2^-$	3646.4	$21/2^-$
456.2	456.4	$5/2^-$	0.0	$7/2^+$
472.2	3169.9	$(19/2^-)$	2697.2	$17/2^-$
476.5	3646.4	$21/2^-$	3169.9	$(19/2^-)$
509.0	700.1	$5/2^-$	191.3	$1/2^-$
514.2	4467.8	$25/2^+$	3953.3	$23/2^+$
527.8	3058.6	$19/2^-$	2531.4	$15/2^-$
533.0	2697.2	$17/2^-$	2164.2	$13/2^-$
535.2	3090.1	$17/2^-$	2554.6	$(15/2^+)$
542.0[†]	4838.1	$(25/2^-)$	4296.1	$23/2^-$
552.5	4199.2	$(23/2^-)$	3646.4	$21/2^-$
558.2	3090.1	$17/2^-$	2531.4	$15/2^-$
558.5	2692.2	$17/2^+$	2133.6	$17/2^+$
563.7	3953.3	$23/2^+$	3389.5	$21/2^+$
564.0	2697.2	$17/2^-$	2133.6	$17/2^+$
574.5	5042.4	$27/2^+$	4467.8	$25/2^+$
588.0	3646.4	$21/2^-$	3058.6	$19/2^-$
591.3	2418.6	$13/2^-$	1827.5	$11/2^-$
608.0	4095.3	$23/2^-$	3487.1	$21/2^-$
614.5	4709.3	$25/2^-$	4095.3	$23/2^-$
616.0[†]	3169.9	$(19/2^-)$	2554.6	$(15/2^+)$
627.5	3453.5	$19/2^-$	2825.6	$17/2^-$
630.0	1605.8	$13/2^+$	975.0	$13/2^+$
661.3	2825.6	$17/2^-$	2164.2	$13/2^-$
735.6	6312.4	$29/2^+$	5576.8	$27/2^+$
741.8	1441.9	$9/2^-$	700.1	$5/2^-$
756.7	3453.5	$19/2^-$	2697.2	$17/2^-$
761.0	3953.3	$23/2^+$	3192.7	$19/2^+$
762.0	3852.8	$21/2^-$	3090.1	$17/2^-$
771.0	6525.0	$31/2^+$	5754.1	$29/2^+$
781.8	4735.0	$25/2^+$	3953.3	$23/2^+$
790.0	3487.1	$21/2^-$	2697.2	$17/2^-$
794.0	3852.8	$21/2^-$	3058.6	$19/2^-$
797.0	7321.7	$(33/2^+)$	6525.0	$31/2^+$
809.3	4296.1	$23/2^-$	3487.1	$21/2^-$
816.0	2164.2	$13/2^-$	1348.0	$9/2^-$
821.1	3646.4	$21/2^-$	2825.6	$17/2^-$
823.3	872.6	$11/2^+$	49.0	$9/2^+$
834.3	2825.6	$17/2^-$	1991.4	$15/2^+$
841.7	5576.8	$27/2^+$	4735.0	$25/2^+$
842.0	4296.1	$23/2^-$	3453.5	$19/2^-$
847.1	4467.8	$25/2^+$	3620.5	$21/2^+$
852.1	2692.2	$17/2^+$	1840.2	$13/2^+$
853.0	901.7	$7/2^-$	49.0	$9/2^+$
862.6	3554.6	$21/2^+$	2692.2	$17/2^+$
864.5	4959.9	$25/2^-$	4095.3	$23/2^-$
865.5	1840.2	$13/2^+$	975.0	$13/2^+$
872.7	872.6	$11/2^+$	0.0	$7/2^+$
884.4	933.3	$11/2^+$	49.0	$9/2^+$
890.0	4510.7	$(23/2^+)$	3620.5	$21/2^+$
891.6	1348.0	$9/2^-$	456.4	$5/2^-$
901.5	901.7	$7/2^-$	0.0	$7/2^+$
906.7	1840.2	$13/2^+$	933.3	$11/2^+$
925.8	975.0	$13/2^+$	49.0	$9/2^+$
925.9	1827.5	$11/2^-$	901.7	$7/2^-$
926.0	2531.4	$15/2^-$	1605.8	$13/2^+$
933.6	933.3	$11/2^+$	0.0	$7/2^+$
942.0	2782.4	$15/2^-$	1840.2	$13/2^+$
949.5	3646.4	$21/2^-$	2697.2	$17/2^-$
950.0	4903.1	$25/2^+$	3953.3	$23/2^+$
954.6	2782.4	$15/2^-$	1827.5	$11/2^-$
976.7	2418.6	$13/2^-$	1441.9	$9/2^-$
985.5	1441.9	$9/2^-$	456.4	$5/2^-$
1011.0	6053.5	$(29/2^+)$	5042.4	$27/2^+$
1016.3	1991.4	$15/2^+$	975.0	$13/2^+$
1029.1	4199.2	$(23/2^-)$	3169.9	$(19/2^-)$
1037.0	4095.3	$23/2^-$	3058.6	$19/2^-$
1058.8	3192.7	$19/2^+$	2133.6	$17/2^+$
1078.4	4467.8	$25/2^+$	3389.5	$21/2^+$

NDS-style output of band drawing



fppt.com

Papers selected for XUNDL exercises

2022Mu09: ^{81}Kr: high-spin: PL-B **827**, 137006 (2022): present compiled dataset needs to be checked thoroughly for data, and through FMTCHK, GTOL codes. Comments need to be added for band structures, and other results.

2018Bu16: PRC **98**, 064320 (2018): **^{109}Rh** from ^{109}Ru B- decay: shape coexistence: level half-lives measured using (beta)gg(t) fast-timing method. These authors reported results in a 2011BuZZ: priv. comm. (data from this in current ENSDF). May ask your tutor for a copy of 2011BuZZ, if available.

2019Ro14: ^{83}Y: high-spin study: PRC **100**, 024327 (2019); level lifetime measurement: Doppler-shift attenuation method. Reaction used: 58NI(32S,A3PG). Lowest levels are not connected to the g.s. in the level scheme. Using data in ENSDF, connecting transitions can be given in the dataset. Check authors' B(E2), transition quadrupole moment (Qt), and deformation parameter (beta2) deductions based on measured lifetimes.

2021Ju03: ^{161}Tb EC decay to ^{161}Dy: Applied Rad. Isotop. **174**, 109770 (2021): precise gamma-ray emission intensities from a metrology lab in Lausanne. Take Eg values from the ENSDF database. ^{161}Tb: important in targeted therapy by SPECT method. Previous studies were in 1984-1985.

Papers for XUNDL exercises

2021JU03: ^{169,171,173}Os: PL-B **820**, 136527 (2021): level lifetime measurements by recoil-distance Doppler-shift method for 13/2+ neutron-orbital bands: 3 datasets.

Reactions: 92MO(83KR,2P4NG): 169OS; 92MO(83KR,2P2NG): 171OS; 92MO(83KR,2PG): 173OS. Consult ENSDF for level energies, and connecting gammas.

2022ZH22: ^{187}Pb: PL-B **829**, 137129 (2022): 142ND(50CR,2P3NG): prompt and delayed gamma rays. On request, some details of gamma-ray data have been obtained from the authors which should be included. Half-life of a microsecond isomer measured.

2022GR08: ^{106}Cd: PL-B 834, 137446 (2022): Coulomb excitation yields: deduced E2 and M1 matrix elements, static quadrupole moments. Consult ENSDF for Eg values and branching ratios. Try deducing B(E2), B(M1) values.

XUNDL datasets

Communicate with your tutor after the workshop, if necessary, to complete the dataset. Send your compilation to your tutor.

All compilations should be completed by November 15, 2022.

Tutors will send me all the datasets, which after some review, will be sent to NNDC for inclusion in the XUNDL database at: www.nndc.bnl.gov/ensdf/xundl/

HAPPY XUNDLING!