Sofia University ‘St. Kl. Ohridski’

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APRENDE

Nuclear structure and decay data evaluation

APRENDE WP4, Task 4.1

APRENDE Experimentalists-Evaluators workshop , Lausanne

07/07/2026

Stefan Lalkovski

Funded by the European Union

Nuclear databases

Nuclear structure:

Nuclear reactions:

Evaluated databases:

- Extensive database freely accessible worldwide
- Experimental data (mostly)

- Several databases
- Theory fit on experimental data (mostly)

ENSDF
Evaluated Nuclear Structure Data File

JEFF-4.0 (Europe)
Joint Evaluated Fission and Fusion Library

ENDF/BVIII.1 (USA)
Evaluated Nuclear Data File

Unevaluated experimental databases:

XUNDL
Experimental Unevaluated Nuclear Data List

EXFOR
Experimental Nuclear Reaction Data Library

Derived, purpose-oriented databases:

RIPL
Reference Input Parameter Library
for theoretical calculations of nuclear reactions

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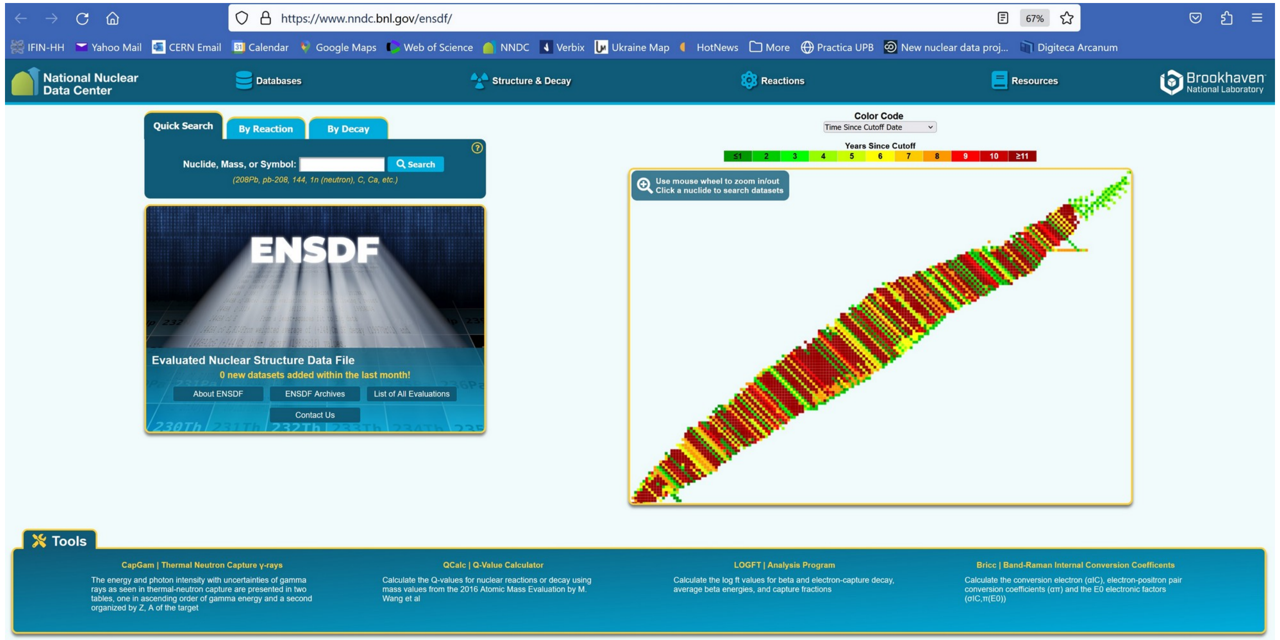
The Evaluated Nuclear Structure Data File: ENSDF



Network: Nuclear Structure and Decay Data (NSDD)

Coordination: IAEA

Hosting: NNDC, Brookhaven National Laboratory, US

Data Centres: 18 worldwide (7 US)

European Data Centres: ATOMKI (HU), IFIN-HH (RO), UniSv. (BG)

3426 nuclides

19709 datasets

- **Sofia's responsibility:** 106, 107, 108, 111, 112;
- Evaluated mass-chains in **Sofia** so far: A=200, 207, 112, 105.
- The evaluation of a mass chain takes 2-3 years and results in a 200 – 400 pages article.

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Aprende activities

WP4 'Nuclear Data evaluation'

Task. 4.1. *Decay data evaluation and education* (M1 – M48)

Partners: Atomki, IFIN-HH, USOF

Aims:

- Training (1 new NSDD evaluator): 2 trainee
- Two mass-chain (ENSDF) evaluations (D4.1, M42)

  A=111(106), 117

Total dedicated effort: 2.7 PY

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Ongoing evaluation of the A=117 mass chain in IFIN

- Hands-on training of Himanshu Singh (IFIN-HH) under the supervision of S. Lalkovsky (Univ. Sofia).
- A=117 is under the responsibility of the IFIN-HH Data Centre. Last time evaluated 17 years ago.
- Proton-rich isotopes assigned to IFIN-HH: ^{117}La, ^{117}Ba, ^{117}Cs, ^{117}Xe, ^{117}Te and ^{117}I.
- ^{117}La, ^{117}Ba, ^{117}Cs, ^{117}Xe – completed
- ^{117}Te – ongoing
- ^{117}I – to be evaluated

117La
21.7 ms
p=100%

117Ba
1.75 s
ε+β+=100%
εp=13%
εα=0.024%

117Cs
8.4 s
ε+β+=100%

117Xe
61 s
ε+β+=100%
εp=2.9e-3%

117I
2.22 min
ε+β+=100%

117Te
62 min
ε+β+=100%

117Sb
2.8 h
ε+β+=100%

117Sn
STABLE
7.68%

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ENSDF – the evaluation process:

1. Gather and sort all experimental data:
   Articles
   theses, reports, private communications

2. Arrange data by type:
- decay 1,
- decay 2, etc.
- reaction 1,
- reaction 2, etc.

3. Build a dataset per decay/reaction

4. Evaluate all data and generate the **Adopted levels and gammas**

$^{117}_{48}Cd_{69}$-1 NUCLEAR DATA SHEETS $^{117}_{48}Cd_{69}$-1

Adopted Levels, Gammas

$Q(\beta^-)$=2525 *5*; S(n)=5777.2 *10*; S(p)=11165 *3*; $Q(\alpha)$=−5253 *7* 2021Wa16

^{117}Cd Levels

Cross Reference (XREF) Flags

A	^{117}Ag β^- decay (5.34 s)	D	^{116}Cd(d,p),^{116}Cd(d,pγ)
B	^{117}Ag β^- decay (72.8 s)	E	^{208}Pb(^{18}O,Fγ)
C	^{252}Cf SF decay		

E(level)†	J^π	$T_{1/2}$	XREF	Comments
0.0	1/2$^+$	2.49 h *4*	ABCDE	%β^-=100 μ=−0.74368 *9* $\delta\langle r^2\rangle$(^{114}Cd,^{117}Cd)=+0.171 fm^2 *2 4* from 2022Ha28 which is a reanalysis of 2018Ha30. μ: weighted average of −0.7437 *1* (2015Fr08) and −0.7436 *2* (2013Yo02). J^π: L(d,p)=0 (1964Ro17); log*ft*=6.4 in ^{117}Ag β- decay (72.8 s). $T_{1/2}$: weighted average from 2.4 h *1* (1975Ta06), 2.42 h *7* (1972Pa13), 2.5 h *2* (1972Gr24), 2.60 h *8* (1969Mo21), 2.52 h *12* (1967Sc37), 2.5 h *1* (1967Ba18), 2.5 h *2* (1966De16). Others: 1939Go02, 1939Li04, 1940La07, 1940Ni03, 1952At25, 1953Co04.
135.37 *18*	3/2$^+$	≤1 ns	AB D	J^π: 135.3γ M1 to 1/2$^+$; L(d,p)=2 (1964Ro17); log*ft*=6.7 in ^{117}Ag β- decay (72.8 s); However, log*ft*=6.06 *3* in ^{117}Ag β- decay (5.34 s) supports 5/2$^+$ assignment. $T_{1/2}$: From γ(t) in 1976Fo10.

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ENSDF Procedures:

<u>For each nucleus:</u>

- Eγ → least-squares fit adjustment → Elevel
- mostly come from HPGe measurements
- Iγ → intensity balance → check for data consistency
  → Iβ
- γ(Θ), α → γ–ray Mult.
- γ–ray Mult., L → J^{π}
- BR

- $T_{1/2}$ from γ(t), Coulex …
- RDDS, DSAM, FT ,,,

- Calculate: BE1, BM1, BE2 …, log*ft*

Typical medium-mass chain: ~15 nuclei, several of which with ~20+ data sets, ~400 lit sources

Open ▾

The ENSDF file:

```
117CD    ADOPTED LEVELS, GAMMAS
117CD  H TYP=FUL$AUT=Z.Elekes and S.Lalkovski$CIT=ENSDF$CUT=1-JUL-2026$
117CD dG $Transition strength is calculated by Java-RULER (version 11-Nov-2025)
117CD  Q 2525     5 5777.2  1011165   3 -5253   7     2021WA16
117CD cL E$From a least-squares fit to E|g, unless otherwise noted
117CD cL E(A)$From {+116}Cd(d,p)
117CD CL BAND(C)$|DJ=2 band, based on (11/2-); CONF$|nh{-11/2}
117CD CL BAND(D)$|DJ=2 band, based on (19/2+)
117CD cG E,RI$From {+117}Ag |b-decay (72.8 s) (1976Fo10), unless otherwise noted
117CD cG E(a),RI(a)$From {+117}Ag |b-decay (5.34 s) (1976Fo10)
117CD cG E(b)$From {+252}Cf SF decay
117CD  XA117AG B- DECAY (5.34 S)
117CD  XB117AG B- DECAY (72.8 S)
117CD  XE252CF SF DECAY
117CD  XC116CD(D,P),116CD(D,PG)
117CD  XD208PB(180,FG)
117CD DG CC$FROM BrIcc v2.3e (17-Jun-2020) 2008Ki07, "Frozen Orbitals" appr.
117CD PN                                                                     6
117CD  L 0.0        1/2+              2.49 H    4
117CDX L XREF=ABCDE$%B-=100
117CD2 L MOMM1=-0.74368 9
117CD cL $|d|4r{+2}|5({+114}Cd,{+117}Cd)=+0.171 fm{+2} {I2} {I4}
117CD2CL from 2022Ha28 which is a reanalysis of 2018Ha30.
117CD CL MOMM1$weighted average of -0.7437 1 (2015Fr08) and -0.7436 2
117CD2CL (2013Yo02)
117CD cL J$L(d,p)=0 (1964Ro17); log{Ift}=6.4 in {+117}Ag |b- decay (72.8 s)
117CD cL T$weighted average from 2.4 h {i1} (1975Ta06), 2.42 h {i7}
117CDacL (1972Pa13), 2.5 h {i2} (1972Gr24), 2.60 h {i8} (1969Mo21), 2.52 h
117CDacL {i12} (1967Sc37), 2.5 h {i1} (1967Ba18), 2.5 h {i2} (1966De16).
117CDacL Others: 1939Go02, 1939Li04, 1940La07, 1940Ni03, 1952At25, 1953Co04
117CD  L 135.37    18 3/2+              1 NS      LE
117CDX L XREF=ABC
117CD cL J$135.3|g M1 to 1/2+; L(d,p)=2 (1964Ro17); log{Ift}=6.7 in {+117}Ag |b-
117CD2cL decay (72.8 s); However, log{Ift}=6.06 {I3} in {+117}Ag |b- decay
117CD2cL (5.34 s) supports 5/2+ assignment
117CD CL T$From |g(t) in 1976Fo10.
117CD  G 135.3      100       M1                      0.1990 28
117CDS G  KC=0.1726 24$LC=0.02150 30$MC=0.00413 6
117CDS G  NC=0.000736 10$OC=4.21E-5 6
117CD cG M$|a(K)exp=0.172 {I20} (1976Fo10)
117CD  L 136.4     2 (11/2-)            3.36 H    5                            CM
117CD DL E         LEVEL ENERGY HELD FIXED IN LEAST-SQUARES ADJUSTMENT
117CD2 L MOMM1=-0.99702 18$MOME2=-0.32 10
117CD CL J$ from systematics
117CD cL $%IT negligible from B(E5)(W.u.)|?4|*10{+5}
117CD cL T$weighted average from 3.4 h {i1} (1975Ta06), 3.31 h {i7}
117CDacL (1972Pa13), 3.4 h {i2} (1972Gr24), 3.50 h {i8} (1969Mo21), 3.10 h
117CDacL {i12} (1967Sc37), 3.3 h {i3} (1966De16); Also, AP 2.7 h (1963Ta12)
117CD cL $|d<r{+2}>{+g,m}=-0.074 mb {I3} (stat) {I6} (syst), -0.059 mb {I5}
117CD2cL (stat) {I5} (syst) (2016Yo01).
117CD CL MOMM1$weighted average of -0.9969 2 (2015Fr08) and -0.9975 4
```

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Adopted Levels, Gammas (continued)

$\gamma(^{117}Cd)$

E_i(level)	J_i^π	E_γ†	I_γ†	E_f	J_f^π	Mult.	α@	Comments
135.37	$3/2^+$	135.3	100	0.0	$1/2^+$	M1	0.1990 *28*	Mult.: α(K)exp=0.172 *20* (1976Fo10).
278.4	$(9/2^-)$	142.0	100	136.4	$(11/2^-)$	M1	0.1742 *24*	Mult.: α(K)exp=0.164 *20* (1976Fo10).
293.6	$(7/2^-)$	(15.4)		278.4	$(9/2^-)$			E_γ: not observed experimentally, but based on obderved γ-γ coinc in 1980Br10.
		157.0 *5*	100	136.4	$(11/2^-)$	E2	0.301 *5*	B(E2)(W.u.)=37.5 *22* Mult.: α(K)exp=0.24 *5* (1976Fo10).
337.71	$(1/2,3/2)^+$	202	4.7	135.37	$3/2^+$			
		337.7	100 *6*	0.0	$1/2^+$	M1+E2	0.0198 *22*	Mult.: α(K)exp=0.025 *8* (1976Fo10).
426.1	$3/2^+$	426.1	100	0.0	$1/2^+$	M1+E2	0.0103 *4*	Mult.: α(K)exp=0.006 *3* (1976Fo10).
442.81	$(1/2,3/2)^+$	104.7 *5*	7.61	337.71	$(1/2,3/2)^+$			
		307.1	100 *11*	135.37	$3/2^+$	M1+E2	0.026 *4*	Mult.: α(K)exp=0.027 *20* (1976Fo10).
		442.5	64 *5*	0.0	$1/2^+$			
498.1	$(7/2)^+$	204.8‡	100‡	293.6	$(7/2^-)$	E1	0.02188 *31*	B(E1)(W.u.)=1.83×10^{-5} *18* Mult.: α(K)exp=0.027 *15* (1976Fo10).
		220.0‡	51‡	278.4	$(9/2^-)$	E1	0.01794 *25*	B(E1)(W.u.)=7.4×10^{-6} *13* Mult.: α(K)exp LT 4.3 (1976Fo10).
		362.0‡	37‡	135.37	$3/2^+$	(E2)	0.01769 *25*	B(E2)(W.u.)=0.54 *10* Mult.: based on reduced electromagnetic strength analysis performed by the evaluators.
522.22	$(5/2^+)$	184.7	33 *12*	337.71	$(1/2,3/2)^+$	M1	0.0852 *12*	Mult.: α(K)exp=0.057 *20* (1976Fo10).
		387.0	100 *5*	135.37	$3/2^+$	M1+E2	0.0134 *9*	Mult.: α(K)exp=0.011 *2* (1976Fo10).
		522.1 *2*	23.5 *16*	0.0	$1/2^+$			
605.8	$(5/2,7/2^-)$	312.2	100 *10*	293.6	$(7/2^-)$	M1+E2	0.0250 *35*	Mult.: α(K)exp=0.037 *20* (1976Fo10).
		327.0	13	278.4	$(9/2^-)$			
639.7	$(15/2^-)$	503.3# *5*	100	136.4	$(11/2^-)$			
665.3	$(3/2^+,5/2^+)$	529.9	85	135.37	$3/2^+$			
		665.4	100	0.0	$1/2^+$			

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Adopted Levels, Gammas

$Q(\beta^-)=2525$ *5*; S(n)=5777.2 *10*; S(p)=11165 *3*; $Q(\alpha)=-5253$ *7*   2021Wa16

^{117}Cd Levels

Cross Reference (XREF) Flags

A	$^{117}Ag\ \beta^-$ decay (5.34 s)	D	^{116}Cd(d,p),^{116}Cd(d,pγ)
B	$^{117}Ag\ \beta^-$ decay (72.8 s)	E	^{208}Pb(^{18}O,Fγ)
C	^{252}Cf SF decay		

E(level)†	J^π	$T_{1/2}$	XREF	Comments
0.0	$1/2^+$	2.49 h *4*	ABCDE	$\%\beta^-=100$ $\mu=-0.74368$ *9* $\delta\langle r^2\rangle(^{114}Cd,^{117}Cd)=+0.171\ fm^2$ *2 4* from 2022Ha28 which is a reanalysis of 2018Ha30. μ: weighted average of -0.7437 *1* (2015Fr08) and -0.7436 *2* (2013Yo02). J^π: L(d,p)=0 (1964Ro17); log*ft*=6.4 in $^{117}Ag\ \beta$- decay (72.8 s). $T_{1/2}$: weighted average from 2.4 h *1* (1975Ta06), 2.42 h *7* (1972Pa13), 2.5 h *2* (1972Gr24), 2.60 h *8* (1969Mo21), 2.52 h *12* (1967Sc37), 2.5 h *1* (1967Ba18), 2.5 h *2* (1966De16). Others: 1939Go02, 1939Li04, 1940La07, 1940Ni03, 1952At25, 1953Co04.
135.37 *18*	$3/2^+$	≤1 ns	AB D	J^π: 135.3γ M1 to $1/2^+$; L(d,p)=2 (1964Ro17); log*ft*=6.7 in $^{117}Ag\ \beta$- decay (72.8 s); However, log*ft*=6.06 *3* in $^{117}Ag\ \beta$- decay (5.34 s) supports $5/2^+$ assignment. $T_{1/2}$: From γ(t) in 1976Fo10.

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Activities in Sofia University

1. Training:

   APRENDE:

   Dr. Orlin Yordanov (INRNE,BAS-BG)-17 months

   Dr. Nikolay Petrov (Sofia University, Bg)

   Postdoc Himanshu Singh identified a trainee evaluator.

   NUCPE:

   other colleagues and students

2. Data evaluation

   APRENDE: 117, 111

   CTBTO: ^{106}Rh, ^{144}Pr

3. Research: γ–ray spectroscopy; half-lives, Ag structure

4. Teaching: 360 hours/year

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Pu nuclear structure and decay data evaluation status

nucleus	Data Center	Cut-off date	XUNDL
239Pu	NNDC	30-Jun-2013	3
240Pu	NNDC	27-Sept-2024	10
241Pu	ORNL	30-Sept-2015	1

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Datasets for ^{239}Pu

Nuclide, Mass, or Symbol: Search

There are 3 corresponding XUNDL (unevaluated) sets

Matching datasets in ENSDF

Retrieve selected ENSDF datasets:

PDF Version ENSDF text format

Dataset	Last Revised	References
Select All		
ADOPTED LEVELS, GAMMAS	2014-11	All references
239NP B- DECAY	2014-11	All references
MUONIC ATOM	2014-11	All references
239AM EC DECAY	2014-11	All references
243CM A DECAY	2014-11	All references
238U(A,3NG)	2014-11	All references
238PU(N,G) E=TH	2014-11	All references
238PU(D,P)	2014-11	All references
239PU(G,G')	2014-11	All references
239PU(N,N')	2014-11	All references
239PU(D,D')	2014-11	All references
COULOMB EXCITATION	2014-11	All references

Retrieve selected ENSDF datasets:

PDF Version ENSDF text format

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^{238}Pu(n,γ) E=th 1975WeZA,1975MaXY

History

Type	Author	Citation	Literature Cutoff Date
Full Evaluation	E. Browne, J. K. Tuli	NDS 122, 293 (2014)	30-Jun-2013

^{239}Pu Levels

E(level)	Jπ[†]	E(level)	Jπ[†]	E(level)	Jπ[†]	E(level)	Jπ[†]
0	$1/2^+$	470.1	$1/2^-$	798.2	1/2,3/2	1099.5	1/2,3/2
7.9	$3/2^+$	492.1	$3/2^-$	805.1	1/2,3/2	(5646.6 *3*)	$1/2^+$
57.3	$5/2^+$	505.4	$(5/2^-)$	825.5	1/2,3/2		
75.7	$7/2^+$	556.6	$(7/2^-)$	888.0	1/2,3/2		
163.8	$9/2^+$	752.5	$1/2^+,3/2$	933.3	1/2,3/2		

[†] From Adopted Levels.

γ(^{239}Pu)

E_γ	I_γ[‡]	E_i(level)	J^π_i	E_f	J^π_f
392.7	0.3[†]	556.6	$(7/2^-)$	163.8	$9/2^+$
429.7	1.4[†]	505.4	$(5/2^-)$	75.7	$7/2^+$
434.9	3.1[†]	492.1	$3/2^-$	57.3	$5/2^+$
448.5	0.2[†]	505.4	$(5/2^-)$	57.3	$5/2^+$
462.2	4.3[†]	470.1	$1/2^-$	7.9	$3/2^+$
470.1	2.4[†]	470.1	$1/2^-$	0	$1/2^+$
484.3	0.4[†]	492.1	$3/2^-$	7.9	$3/2^+$
492.2	2.3[†]	492.1	$3/2^-$	0	$1/2^+$
497.6	1.4[†]	505.4	$(5/2^-)$	7.9	$3/2^+$
499.4	0.5[†]	556.6	$(7/2^-)$	57.3	$5/2^+$
695.6	0.4[†]	752.5	$1/2^+,3/2$	57.3	$5/2^+$
744.6	0.8[†]	752.5	$1/2^+,3/2$	7.9	$3/2^+$
752.5	1.0[†]	752.5	$1/2^+,3/2$	0	$1/2^+$
790.4	1.7[†]	798.2	1/2,3/2	7.9	$3/2^+$

^{238}Pu(n,γ) E=th 1975WeZA,1975MaXY (

γ(^{239}Pu) (continued)

E_γ	I_γ[‡]	E_i(level)	J^π_i	E_f	J^π_f
5638.0		(5646.6)	$1/2^+$	7.9	$3/2^+$
5646.6 *5*	2.0 *5*	(5646.6)	$1/2^+$	0	$1/2^+$

[†] Relative intensities.
[‡] For intensity per 100 neutron captures, multiply by 0.10.