Title
TABLE OF RADIOACTIVE ISOTOPES

Authors
Firestone, R.B.
Browne, E.

Publication Date
1985-09-01

LBL-20363

Lawrence Berkeley Laboratory
UNIVERSITY OF CALIFORNIA

Presented at the ACS Symposium on Recent Advances in the Study of Nuclei Off the Line of Stability, Chicago, IL, September 8-13, 1985; and to be published in the Proceedings

TABLE OF RADIOACTIVE ISOTOPES

R.B. Firestone and E. Browne

September 1985

NUCLEAR SCIENCE DIVISION

Prepared for the U.S. Department of Energy under Contract DE-AC03-76SF00098

DISCLAIMER

TABLE OF RADIOACTIVE ISOTOPES

R.B. Firestone and E. Browne
Lawrence Berkeley Laboratory, University of California, Berkeley CA 94720

The *Table of Radioactive Isotopes* will be published in 1986. It will contain recommended radiation data for all radioactive isotopes and is produced from the LBL Isotopes Project's extended Evaluated Nuclear Structure Data File [ENSDF] database. The book will include mass-chain decay schemes updated from the 7th Edition of the *Table of Isotopes* [LED78] and tabular data with adopted γ-ray, alpha particle, atomic-electron, beta, and internal bremsstrahlung energies and intensities. Average radiation energies per disintegration will be provided when possible. The data presented are generally derived from ENSDF with some updating. In addition to the tabular data, there will be text and appendices. The database from which the *Table of Radioactive Isotopes* is being produced is available to users through the LBL computers.

1. Contents

The *Table of Radioactive Isotopes* is intended primarily for applied users of nuclear data. Figs. 1 and 2 are pages from the *Table of Radioactive Isotopes* for A=221. These pages were produced from the LBL Isotopes Project extended ENSDF database (LBL/ENSDF) [ENSDF,BRO82]. Mass-chain decay schemes were manually updated from the *Table of Isotopes* [LED78] and tabular data prepared using TROFF(a UNIX text processor) with a phototypesetter. Some features of the *Table of Radioactive Isotopes* are discussed here.

1.1. Mass-Chain Decay Schemes

The mass-chain decay scheme for A=221 is shown at the beginning of Fig. 1. A reference to the most recent evaluation of A=221 is given at the top of the scheme. The alpha-decay nuclei from A=225 are shown off-scale, and the mass-chain decay scheme is presented to the scale(keV) indicated at the left. For each mass-chain decay scheme the scale defines zero as the minimum of the mass parabola. Q-values are from Wapstra [WAP85]. Half-lives are from ENSDF with selective updates from [INDC83] and the 1983 GE *Chart of the Nuclides* [WAL84a] with details provided by F. William Walker [WAL84b]. Mass-chain decay schemes show decay branching ratios including delayed particle emission and exotic decay modes. Ground states and isomers with either $t_{1/2}>100$ ms or observed particle or beta decay mode(s) are included.

1.2. Headers

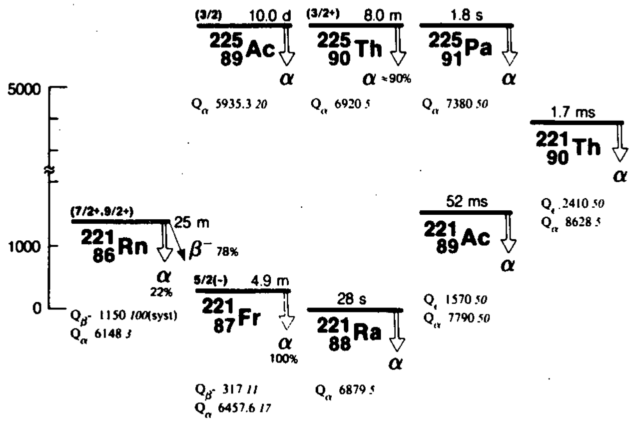
For each isotope a summary of the decay mode(s), mass excess, specific activity, and principal means of production are presented. Half-life units have been standardized (e.g. 36 h=1.5 d and 0.5 s=500 ms). Means of production are from the *Table of Isotopes.* Abundances are given for naturally occurring isotopes [HOL83].

1.3. Photon Tables

For each isotope γ-ray energies and intensities are presented in an energy ordered table with the decay mode indicated when more than one is possible. γ-ray multipolarities and percentage admixtures are given where parentheses indicates some uncertainty in the assignment, and square brackets are used to indicate multipolarities inferred primarily from the level scheme. Energies have been fit by least-squares with respect to the level scheme to obtain the best values for all transitions. Intensities were averaged to obtain the best γ-ray branching ratios from each level as described by Tepel [TEP80] and adopted using the method of Lederer [LED82]. Absolute intensities per hundred disintegrations of the parent nucleus are given when possible. Otherwise, relative intensities normalized to 100 for the strongest γ ray are given. Systematic uncertainties are footnoted on the table, and equilibrium corrections were made and indicated

A = 221

NDS 27, 681 (1979)



$^{221}_{86}$Rn(25 *2* min)

Mode: β-(78 *1* %), α(22 *1* %)
Δ: 14410 *100* keV syst
SpA: 3.4×10^7 Ci/g
Prod: protons on Th

Alpha Particles (^{221}Rn)

$\langle\alpha\rangle$=1318.1 keV

α(keV)	α(%)
5778 *3*	1.8
5788 *3*	2.2
6037 *3*	18

Photons (^{221}Rn)

$\langle\gamma\rangle$=120 *5* keV

γ_{mode}	γ(keV)	γ(%)†
Po L_ℓ	9.658	~0.011
Fr L_ℓ	10.381	~0.8
Po L_α	11.119	~0.22
Fr L_α	12.017	~14
Po L_η	12.085	~0.0032
Fr L_η	13.255	~0.27
Po L_β	13.502	~0.21
Fr L_β	14.775	~16
Po L_γ	15.871	~0.04
Fr L_γ	17.439	~3
$\gamma_{\beta-}$M1(+E2)	36.65 *4*	>0.008
$\gamma_{\beta-}$M1(+E2)	38.51 *3*	>0.010
$\gamma_{\beta-}$[E1]	49.20 *4*	0.071 *10*
$\gamma_{\beta-}$[E1]	57.77 *4*	0.023 *7*
$\gamma_{\beta-}$M1	62.93 *4*	0.143 *17*
$\gamma_{\beta-}$M1+17%E2	64.23 *4*	0.267 *20*
$\gamma_{\beta-}$E2	69.85 *4*	0.041 *9*
$\gamma_{\beta-}$E2	71.71 *4*	0.119 *12*
$\gamma_{\beta-}$E2(+<41%M1)	73.60 *6*	~0.0044
$\gamma_{\beta-}$E1	73.84 *4*	0.53 *3*

Photons (^{221}Rn) (continued)

γ_{mode}	γ(keV)	γ(%)†
$\gamma_{\beta-}$(M1+~20%E2)	74.90 *6*	0.17 *7*
Po $K_{\alpha2}$	76.858	~0.32
Po $K_{\alpha1}$	79.290	~0.5
Fr $K_{\alpha2}$	83.229	8.2 *8*
Fr $K_{\alpha1}$	86.105	13.6 *12*
$\gamma_{\beta-}$M1	87.39 *4*	0.21 *4*
Po $K_{\beta1}'$	89.639	~0.19
Po $K_{\beta2}'$	92.673	~0.06
$\gamma_{\beta-}$M1(+E2)	94.87 *4*	0.12 *5*
$\gamma_{\beta-}$M1+37%E2	96.17 *5*	~0.022
Fr $K_{\beta1}'$	97.272	4.9 *5*
$\gamma_{\beta-}$M1+3.3%E2	99.58 *4*	0.16 *3*
$\gamma_{\beta-}$E1	99.82 *6*	2.8 *6*
Fr $K_{\beta2}'$	100.599	1.56 *15*
$\gamma_{\beta-}$(M1+~26%E2)	100.88 *3*	0.29 *7*
$\gamma_{\beta-}$M1+E2	103.44 *4*	0.050 *13*
$\gamma_{\beta-}$M1+22%E2	108.36 *3*	2.19 *13*
$\gamma_{\beta-}$[E1]	111.56 *3*	2.15 *12*
$\gamma_{\beta-}$	119.87 *10*	0.29 *4*
$\gamma_{\beta-}$[E1]	123.76 *5*	~0.08
$\gamma_{\beta-}$M1+E2	124.81 *6*	~0.022
$\gamma_{\beta-}$(E1)	126.23 *7*	0.22 *3*
$\gamma_{\beta-}$	129.19 *4*	0.22 *3*
$\gamma_{\beta-}$	133.70 *10*	0.54 *10* ?
$\gamma_{\beta-}$(E1)	135.01 *7*	0.65 *6*
$\gamma_{\beta-}$(M1+~39%E2)	144.67 *5*	0.55 *20*
$\gamma_{\beta-}$(E1)	145.15 *4*	0.69 *14*
$\gamma_{\beta-}$E1	150.08 *3*	4.4 *3*
$\gamma_{\beta-}$[E1]	152.64 *4*	~0.2 ?
$\gamma_{\beta-}$[E1]	153.93 *4*	0.83 *6*
$\gamma_{\beta-}$M1+7.5%E2	157.24 *3*	0.23 *4*
$\gamma_{\beta-}$	168.88 *13*	0.27 *3*
$\gamma_{\beta-}$	170.91 *4*	0.47 *4*
$\gamma_{\beta-}$E1	178.39 *3*	0.86 *6*
$\gamma_{\beta-}$[E1]	186.12 *5*	~0.009
$\gamma_{\beta-}$E1	186.39 *4*	20.4 *12*
$\gamma_{\beta-}$E1	187.99 *5*	~0.2
$\gamma_{\beta-}$M1+37%E2	195.75 *3*	0.106 *23*
$\gamma_{\beta-}$	197.79 *12*	0.74 *9*
$\gamma_{\beta-}$(E1)	216.86 *4*	2.3 *3*
$\gamma_{\beta-}$[E1]	224.64 *4*	~0.036
$\gamma_{\beta-}$	240.76 *4*	0.70 *7*
$\gamma_{\beta-}$	253.29 *6*	
$\gamma_{\beta-}$[E1]	253.51 *4*	0.55 *9*
γ_α	254.2 *3*	~2
$\gamma_{\beta-}$	256.24 *5*	0.33 *8*

Photons (^{221}Rn) (continued)

γ_{mode}	γ(keV)	γ(%)†
γ_α(M1+E2)	264.68 *4*	1.14 *8*
$\gamma_{\beta-}$	273.5 *25*	0.46 *20*
$\gamma_{\beta-}$(E1)	279.27 *3*	1.85 *12*

† uncert(syst): 9.8% for α, 8.5% for β-

Atomic Electrons (^{221}Rn)

$\langle e\rangle$=56 *6* keV

e_{bin}(keV)	$\langle e\rangle$(keV)	e(%)
7	1.23	17.0 *13*
10 - 14	0.11	1.0 *3*
15	2.8	~19
16 - 17	0.039	~0.24
18	2.6	~15
19	2.2	~12
20	0.23	<2
21	1.8	<18
22	1.8	<17
23	2.0	~9
24 - 32	1.0	~3
33	1.3	~4
34 - 43	3.0	8 *4*
44	1.2	2.7 *7*
45	0.055	0.122 *15*
46	1.5	3.2 *6*
48 - 53	1.39	2.8 *5*
54	1.09	2.03 *21*
55 - 56	1.22	2.2 *5*
57	1.27	2.2 *4*
58 - 84	6.8	9.8 *10*
85	1.58	1.85 *17*
86 - 89	0.37	0.43 *15*
90	4.0	4.4 *5*
91 - 103	3.0	3.1 *8*
104	1.12	1.08 *11*
105 - 154	5.7	4.6 *8*
155 - 160	0.34	~0.22
161	1.3	<2
163 - 213	2.7	1.6 *5*
214 - 262	1.5	0.64 *20*
264 - 279	0.07	0.027 *12*

XBL 8411-8848

Fig. 1. A page for A=221

Continuous Radiation (^{221}Rn)

⟨β-⟩=236 keV;⟨IB⟩=0.23 keV

E_{bin}(keV)		⟨ ⟩(keV)	(%)
0 - 10	β-	0.072	1.43
	IB	0.0113	
10 - 20	β-	0.215	1.44
	IB	0.0108	0.075
20 - 40	β-	0.87	2.89
	IB	0.020	0.070
40 - 100	β-	6.1	8.8
	IB	0.050	0.077
100 - 300	β-	55	28.0
	IB	0.092	0.055
300 - 600	β-	120	27.9
	IB	0.040	0.0101
600 - 1120	β-	54	7.6
	IB	0.0041	0.00062

$^{221}_{87}$Fr(4.9 *2* min)

Mode: α
Δ: 13255 *11* keV
SpA: 1.73×10^8 Ci/g
Prod: descendant ^{229}Th

Alpha Particles (^{221}Fr)

⟨α⟩=6357 *53* keV

α(keV)	α(%)
5689 *3*	~0.002
5697 *4* ?	~0.0010
5774.4 *7*	0.06 *1*
5783 *4*	0.005 *2*
5813 *3*	~0.004
5925.1 *7*	0.03 *1*
5939.3 *7*	0.17 *3*
5965.9 *7*	0.08 *1*
5979.7 *7*	0.49 *3*
6037 *3*	~0.003
6075.1 *7*	0.15 *3*
6127.0 *7*	15.1 *2*
6243.3 *7*	1.34 *10*
6341.0 *7*	83.4 *8*

Photons (^{221}Fr)

⟨γ⟩=27.7 *8* keV

γ_{mode}	γ(keV)	γ(%)†
At L_ℓ	9.897	0.042 *6*
At L_α	11.414	0.79 *10*
At L_η	12.466	0.0167 *17*
At L_β	13.911	0.96 *11*
At L_γ	16.361	0.199 *24*
At $K_{\alpha2}$	78.947	0.85 *11*
At $K_{\alpha1}$	81.517	1.41 *18*
At $K_{\beta1}'$	92.136	0.50 *7*
At $K_{\beta2}'$	95.265	0.155 *20*
γ	97.2 *3*	~0.019
γ M1(+14%E2)	99.51 *13*	0.10 *4*
γ (M1)	118.47 *13*	~0.035
γ (M1+E2)	149.99 *20*	0.07 *3*
γ	171.29 *20*	0.07 *3*
γ E2	217.98 *4*	10.9 *4*
γ	282.54 *15*	~0.009
γ	324.10 *20*	~0.017
γ	359.09 *20*	~0.035
γ	382.05 *15*	~0.035
γ	409.1 *2*	0.13 *4*

† 6.9% uncert(syst)

Atomic Electrons (^{221}Fr)

⟨e⟩=8.44 *19* keV

e_{bin}(keV)	⟨e⟩(keV)	e(%)
4 - 14	0.21	2.2 *4*
17	0.183	1.08 *15*
23 - 67	0.15	0.41 *16*
74 - 118	0.53	0.62 *13*
122	1.83	1.50 *6*
133 - 171	0.16	0.11 *4*
187	0.005	<0.005
200	0.477	0.238 *9*
201	2.16	1.07 *4*
204	1.18	0.581 *22*
214	0.73	0.340 *13*
215	0.350	0.163 *6*
217	0.286	0.132 *5*
218 - 266	0.092	0.041 *7*
268 - 313	0.06	~0.020
320 - 368	0.010	~0.0028
378 - 409	0.017	~0.004

$^{221}_{88}$Ra(28 *2* s)

Mode: α
Δ: 12938 *8* keV
SpA: 1.80×10^9 Ci/g
Prod: descendant ^{229}U

Alpha Particles (^{221}Ra)

⟨α⟩=9999 *250* keV

α(keV)	α(%)
6160 *25* ?	~0.3
6254 *10*	0.7 *3*
6400 *25* ?	~0.3
6460 *25* ?	~0.4
6578 *5*	3 *1*
6585 *3*	8 *1*
6608 *3*	35 *2*
6669 *3*	21 *2*
6758 *3*	31 *2*

Photons (^{221}Ra)

⟨γ⟩=43 *4* keV

γ_{mode}	γ(keV)	γ(%)
γ	90.2 *19*	15 *2*
γ	152.3 *19*	13 *2*
γ	176.1 *19*	2.0 *5*
γ	220 *10*	~0.10
γ	294 *10*	~0.6
γ	321 *10*	~0.7
γ	416 *10*	~0.50

$^{221}_{89}$Ac(52 *2* ms)

Mode: α
Δ: 14500 *50* keV
SpA: 7.4×10^{10} Ci/g
Prod: descendant ^{225}Pa; ^{208}Pb(^{19}F,α2n); ^{205}Tl(^{22}Ne,α2n); ^{208}Pb(^{16}O,p2n); ^{208}Pb(^{18}O,p4n)

Alpha Particles (^{221}Ac)

⟨α⟩=7720 *930* keV

α(keV)	α(%)
7170 *10*	~2
7375 *10*	~10
7440 *15*	20 *5*
7645 *10*	70 *10*

$^{221}_{90}$Th(1.68 *6* ms)

Mode: α
Δ: 16916 *13* keV
SpA: 7.4×10^{10} Ci/g
Prod: ^{208}Pb(^{16}O,3n); ^{208}Pb(^{22}Ne,α5n); ^{208}Pb(^{20}Ne,α3n); ^{209}Bi(^{19}F,α3n)

Alpha Particles (^{221}Th)

⟨α⟩=8330 *310* keV

α(keV)	α(%)
7733 *8*	6 *1*
8146 *5*	56 *3*
8472 *5*	39 *2*

XBL 8411-8849

Fig. 2. A page for A=221

where necessary. X-ray intensities were calculated for K, L_1, L_2, and L_3 vacancies produced by internal conversion and electron capture processes. Conversion coefficients were interpolated from the tables of Rösel et al [RÖS78] for Z=30-104 and from Band et al [BAN76] for Z<30. EC radial wavefunctions and exchange and overlap corrections were adopted from Bambynek et al [BAM77]. Fluorescence yields, Auger yields, and Coster-Kronig yields are from Krause [KRA79]. K_α, K_β, L_α, L_β, L_γ, L_η, and L_ℓ x-ray branching ratios were taken from a combination of experiment [SAL74] and theory [SCO74a,SCO74b]. X-ray energies were calculated from the binding energies of Larkin [LAR77] except for Z=84-103 which are from Porter and Friedman [POR78].

1.4. Atomic Electron Tables

Calculated energies and intensities for electrons from internal conversion for all atomic subshells and Auger electrons with energies above the M_1 binding energy are presented. Conversion coefficients from Rösel et al [RÖS78] were used. Theoretical Auger transition probabilities were taken from Chen et al [CHE79]. Electron lines are binned in 1-keV intervals with the most energetic bins shown discretely while grouping the remaining data. The total average energy per disintegration is shown at the top of the table and for each energy range within the table. The table also shows the absolute intensity of electrons per hundred disintegrations for each bin.

1.5. Continuous Radiations

Beta spectra for all decay branches were calculated, summed, and binned in standard intervals. The calculations are described by Gove and Martin [GOV71]. Internal bremsstrahlung is also calculated for β^- and β^+ as in [KNI36], and for ϵ decay as described in Bambynek et al [BAM77] and binned in standard intervals. The total average energy per decay is given for each mode at the top of the table and for each standard bin. The intensity in betas or photons per hundred disintegrations is also given for each bin.

1.6. Particle Tables

Alpha-particle energies were analyzed in the same manner as γ-ray energies to obtain recommended values. Absolute intensities per hundred disintegrations are given when possible. Average energies per disintegration are given at the top of each table. Tables of proton-, delayed-proton, delayed-alpha, and delayed-neutron energies and intensities are presented when available.

1.7. General Features

A rounding factor of 25 in the last two significant digits was used. Uncertainties were calculated for all values. For quantities calculated from theoretical or semi-empirical values, the uncertainties were estimated. When the input data included no explicit uncertainties, estimated values were supplied.

1.8. Text and Appendices

In addition to the tabular data there are text and appendices. The inside front cover has a quick-reference definition table to facilitate usage of the book. A thorough discussion of the book is given in the introduction. The following appendices are included.

1.8.1. Atomic Properties

Information necessary to calculate the production of vacancies in the K, L_1, L_2, and L_3 atomic shells from electron capture, internal conversion, and E0 decay are presented. Tables of atomic x-ray energies and intensities and Auger-electron intensities are given for Z=5-104.

1.8.2. Interaction of Radiation with Matter

Photon absorption as well as ranges and stopping powers for charged particles in various elements are graphically presented. Positron annihilation including annihilation in flight is discussed. Calculations for internal bremsstrahlung are also given.

1.8.3. Useful Tables

Tables of fundamental constants, conversion factors, and nuclear spectroscopy standards are presented. Also, energy ordered alpha-particle and principal γ-ray tables have been prepared from the LBL/ENSDF database. In addition, a table of average energies per disintegration for well-characterized isotopes is shown.

2. LBL/ENSDF Database

The database from which the *Table of Radioactive Isotopes* is produced is available through the LBL computers. This database contains the numerical information of the ENSDF file, Wapstra's 1983 mass table [WAP84], and the data from which the *Table of Radioactive Isotopes* is produced. The database can be accessed through the DATATRIEVE database management system. DATATRIEVE uses simple English-like commands to perform Boolean algebraic searches of the data. Procedures can be written in DATATRIEVE to perform complicated searches and data can be retrieved via VAX/VMS(DCL) procedures and processed by Fortran programs. A library of interactive programs is available to calculate internal conversion coefficients, atomic electron spectra, x-ray and Auger-electron yields, average energies, and level scheme balances. Additional programs to evaluate nuclear data and retrieve information are continually being developed. Prospective users of this database are encouraged to contact the Isotopes Project for further information.

2.1. Contents

The LBL/ENSDF database contains separate data files (domains) and identifiers to link the information in the separate domains. All domains can be searched by A, Z, and a dataset identification code.

2.1.1. Directory

The Directory is a complete index to the decays and reactions covered in the LBL/ENSDF database. It can be searched by A or Z of the parent(target) or daughter(product) and by decay or reaction type. The Directory also provides an identifying code connecting the datasets to their associated data.

2.1.2. Levels

The Levels domain contains level energies, spins, parities, half-lives, and Nilsson quantum numbers for each level observed with an associated decay or reaction dataset. For each isotope there is an adopted level set, and identification codes connect the experimental levels to the adopted levels.

2.1.3. Parents

The Parents domain contains radioactive parents cross-referenced to the associated adopted levels. This domain also contains normalizations necessary to obtain beta or γ-ray intensities per hundred disintegrations and branching ratios for each mode of decay.

2.1.4. Gammas

The Gammas domain contains γ-ray energies, intensities, multipolarities, and total conversion coefficients. This domain also contains identifiers connecting the initial and final levels for the γ-ray transition to both the experimental and adopted levels.

2.1.5. Betas and EC

These domains contain beta intensities, log*ft* values, measured endpoint energies, and identifiers connecting the initial and final levels to the adopted level dataset.

2.1.6. Table of Radioactive Isotopes (ELECTRONS, GAMEG, GAMINT, HBKALP, HBKLEV)

The adopted γ-ray, x-ray, alpha particle, and atomic electron data in the *Table of Radioactive Isotopes* are available in these domains. Adopted levels from radioactive decay (not shown in the book) are also available.

2.1.7. The 1983 Atomic Mass Table

The most recent mass evaluation of Wapstra (WAP85) is available in this domain. This includes mass excesses, decay Q-values, and particle separation energies.

2.2. Usage

The LBL/ENSDF database is available on the LBL VAX-8600 computer cluster. This cluster can be accessed by direct dial-up, and via DECnet, MILNET, and TYMNET networks. The database can be searched using the DATATRIEVE database management system. DATATRIEVE uses simple English-like commands and Boolean algebra to search the data. Some examples are given below.

2.2.1. HELP, SHOW, and READY

A complete description of all commands, their effects, and examples of how to use them are available by typing HELP. The SHOW command gives a dictionary of DATATRIEVE data, e.g. SHOW DOMAINS will list all of the domains in the LBL/ENSDF database. Before a domain can be used it must be readied, e.g. READY LEVELS prepares the level domain for usage.

2.2.2. FIND

The FIND command collects a group of data records from a readied domain. This collection is the "current" collection and will be replaced by subsequent FIND commands. For example, to find all parents with A=243 type

```
READY PARENTS
FIND PARENTS WITH AP=243
```

To narrow the collection to only records with A=243 and Z=94 type

```
FIND CURRENT WITH ZP=94
```

Other Boolean expressions can be used, e.g. GT, GE, LT, LE, NE, BT(between) with the FIND command.

2.2.3. SORT

After establishing a collection of records with FIND, the SORT command can be used to order the records. For example to find γ rays in ^{231}Pa with energy greater than 200 keV, and sort them by descending energy, type

```
READY GAMMAS
FIND GAMMAS WITH A=231 AND Z=91
FIND CURRENT WITH EG GT 200
SORT BY DESC EG
```

2.2.4. PRINT

The PRINT command displays the results of a search in simple tabular format with column headings. If the example above for the SORT command is followed by

```
FOR CURRENT PRINT EG,DEG,IG,DIG
```

the following table is generated.

G-ENERGY	ENERGY-ERROR	INTENSITY	INTENS.-ERROR
351.80000	.10000	.00007	.00001
320.15000	.08000	.00011	.00001
317.87000	.08000	.00008	.00001
311.00000	.05000	.00290	.00020
308.78000	.07000	.00039	.00004
274.10000	.10000	.00003	.00001
267.62000	.08000	.00116	.00013
250.45000	.07000	.00065	.00007
249.60000	.07000	.00078	.00008
242.50000	.04000	.00084	.00008
240.27000	.05000	.00028	.00003
236.01000	.03000	.00920	.00060
236.00000		.20000	
220.00000	4.00000	.80000	
217.94000	.03000	.04000	.00300

2.2.5. Programs and Procedures

A menu of programs and procedures is provided for users of the LBL/ENSDF database. There are programs to calculate internal conversion coefficients, x-rays produced during decay, statistical analysis of γ-ray energies and intensities, and physics analysis of level scheme data. Also, there are procedures to produce tables of alpha particles, γ rays, electrons, and continuous radiation. Additional programs to calculate log*ft* values and $\gamma\gamma$ angular correlations will be added. Within DATATRIEVE users can write procedures to perform repetitive or complex searches. Data can also be retrieved using VAX/VMS(DCL) procedures and Fortran programs.

References

[BAM77] W. Bambynek et al., Rev. Mod. Phys. **49**, 77(1977).

[BAN76] I.M. Band, M.B. Trzhaskovskaya, and M.A. Listengarten, Atomic Data and Nucl. Data Tables **18**, 433 (1976).

[BRO82] *Implementation of the Evaluated Nuclear Structure Data File into DATATRIEVE*, a report to the National Academy of Sciences Panel on Basic Nuclear Data Compilations by E. Browne and R.B. Firestone, LBL (1982).

[CHE79] M.H. Chen et al., Atomic Data and Nucl. Data Tables **24**, 13(1979).

[ENSDF] *Evaluated Nuclear Structure Data File* edited and maintained by the National Nuclear Data Center, Brookhaven National Laboratory on behalf of the International Network for Nuclear Structure Data Evaluation.

[GOV71] N.B. Gove and M.J. Martin, Nuclear Data Tables **10**, 206(1971).

[HOL84] N.E. Holden and R.L. Martin, Pure and Applied Chemistry **56**, 675(1984).

[INDC83] *Proposed Recommended List of Heavy Element Radionuclide Decay Data*; A. Lorenz, editor; IAEA International Nuclear Data Committee, INDC(NDS)-149/NE(1983).

[KNI36] J.K. Knipp and G.E. Uhlenbeck, Physica **3**, 425(1936).

[KRA79] M.O. Krause, J. Phys. Ref. Data **8**, 307(1979).

[LAR77] F.B. Larkins, Atomic Data and Nucl. Data Tables **20**, 338(1977).

[LED78] *Table of Isotopes*, 7^{th} edition: C.M. Lederer and V.S. Shirley, editors; E. Browne, J.M. Dairiki, and R.E. Doebler principal authors; A.A. Shihab-Eldin, L.J. Jardine, J.K. Tuli, and A.B. Buryn, authors, John Wiley and Sons, Inc., New York(1978).

[LED82] C.M. Lederer, Nuclear Data Network Memorandum of 13 April, 1982.

[POR78] F.T. Porter and M.S. Friedman, J. Phys. Chem. Ref. Data **7**, 1267(1978).

[RÖS78] F. Rösel et al., Atomic Data and Nucl. Data Tables **21**, 291(1978).

[SAL74] S.I. Salem et al., Atomic Data and Nucl. Data Tables **14**, 91(1974).

[SCO74a] J.H. Scofield, Atomic Data and Nucl. Data Tables **14**, 121(1974).

[SCO74b] J.H. Scofield, Phys. Rev. C**10**, 1041(1974).

[TEP80] J.W. Tepel in the Summary Report of the IAEA Advisory Group Meeting on Nuclear Structure and Decay Data, IAEA report INDC(NSD)-115/NE, 121(1980).

[WAL84a] *Chart of the Nuclides*, 13th Edition; prepared by F.W. Walker, D.G. Miller, and F. Feiner, Knolls Atomic Power Laboratory(1984).

[WAL84b] F.W. Walker, private communication(1984).

[WAP85] A.H. Wapstra et al., Nucl. Phys. A**432**, 1(1985).

This work was supported by the Director, Office of Energy Research, Division of Nuclear Sciences of the Basic Energy Sciences Program of the U.S. Department of Energy under contract DE-AC03-76SF00098.