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EVALUATED NUCLEAR STRUCTURE DATA FILE

A Manual for Preparation of Data Sets

J.K. Tuli

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CONTENTS

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I. INTRODUCTION

This manual[1] describes the organization and structure of the Evaluated Nuclear Structure Data File (**ENSDF**). This computer-based file is maintained by the National Nuclear Data Center (NNDC) at Brookhaven National Laboratory for the international Nuclear Structure and Decay Data Network.[2]

For every mass number (presently, $A \leq 263$), the Evaluated Nuclear Structure Data File (**ENSDF**) contains evaluated structure information. For masses $A \geq 45$, this information is documented in the *Nuclear Data Sheets;* for $A < 45$, **ENSDF** is based on compilations published in the journal *Nuclear Physics*. The information in **ENSDF** is updated by mass chains with a present cycle time of approximately six years.

The author gratefully acknowledges many suggestions and comments received during the preparation of this manual. Special thanks are due to M. J. Martin (ORNL), C. M. Lederer (U.C., Berkeley), R. L. Bunting (INEL), A. Lorenz (IAEA), D. E. Alburger (BNL) and the following colleagues at NNDC: S. Pearlstein, M. R. Bhat, T. W. Burrows, R. R. Kinsey, C. L. Dunford and B. J. Barton. P. Dixon (NNDC) helped with the production of this report. This research was supported by the Office of Basic Energy Sciences, U. S. Department of Energy.

*Designed by W. B. Ewbank at the Nuclear Data Project, Oak Ridge National Laboratory.

[1]This is a revision of the Nuclear Data Project, Oak Ridge National Laboratory, report of the same name [ORNL-5054/R1 (February 1978)] by W. B. Ewbank and M. R. Schmorak.

[2]Coordinated by the International Atomic Energy Agency, Vienna – see Appendix C for list of evaluation centers.

II. GENERAL ORGANIZATION AND STRUCTURE OF THE DATA FILE

A. General Organization

The Evaluated Nuclear Structure Data File (**ENSDF**) is made up of a collection of "data sets" which present one of the following kinds of information:

1. The evaluated results of a *single experiment*, e.g., a radioactive decay or a nuclear reaction.
2. The combined evaluated results of a number of experiments of the same kind, e.g., (Heavy ion, $xn\gamma$), Coulomb excitation, etc.
3. The adopted properties of the nucleus.
4. The references used in all the data sets for the given mass number. This data set is based upon reference codes (key numbers) used in various data sets for a given mass number and is added to the file by NNDC.
5. The summary information for a mass chain giving information, e.g., evaluator's name and affiliations, cutoff date, Nuclear Data Sheets publication details, etc.

The data sets in ENSDF are organized by their mass number. Within a mass number the data sets are of two kinds:

i. Data sets which contain information pertaining to the complete mass chain. These data sets contain information of the type (4) and (5) given above.

ii. Data sets belonging to a given nucleus (Z-value).

Data sets (ii), i.e. for a given nucleus (Z-value), consist of the following:

a. Adopted data set (only one per Z-value) giving adopted properties of the levels and radiations seen in that nucleus.

b. Data sets giving information of the type (1) or (2) above.

If there is more than one data set of type (1) or (2) for a given nucleus, then an adopted data set is *required* for that nucleus. If there is only one data set for a given nucleus, then that set is assumed also to present the adopted properties for that nucleus.

The general organization of ENSDF is shown schematically in Fig. 1.

Evaluated Nuclear Structure Data File

Organization Chart

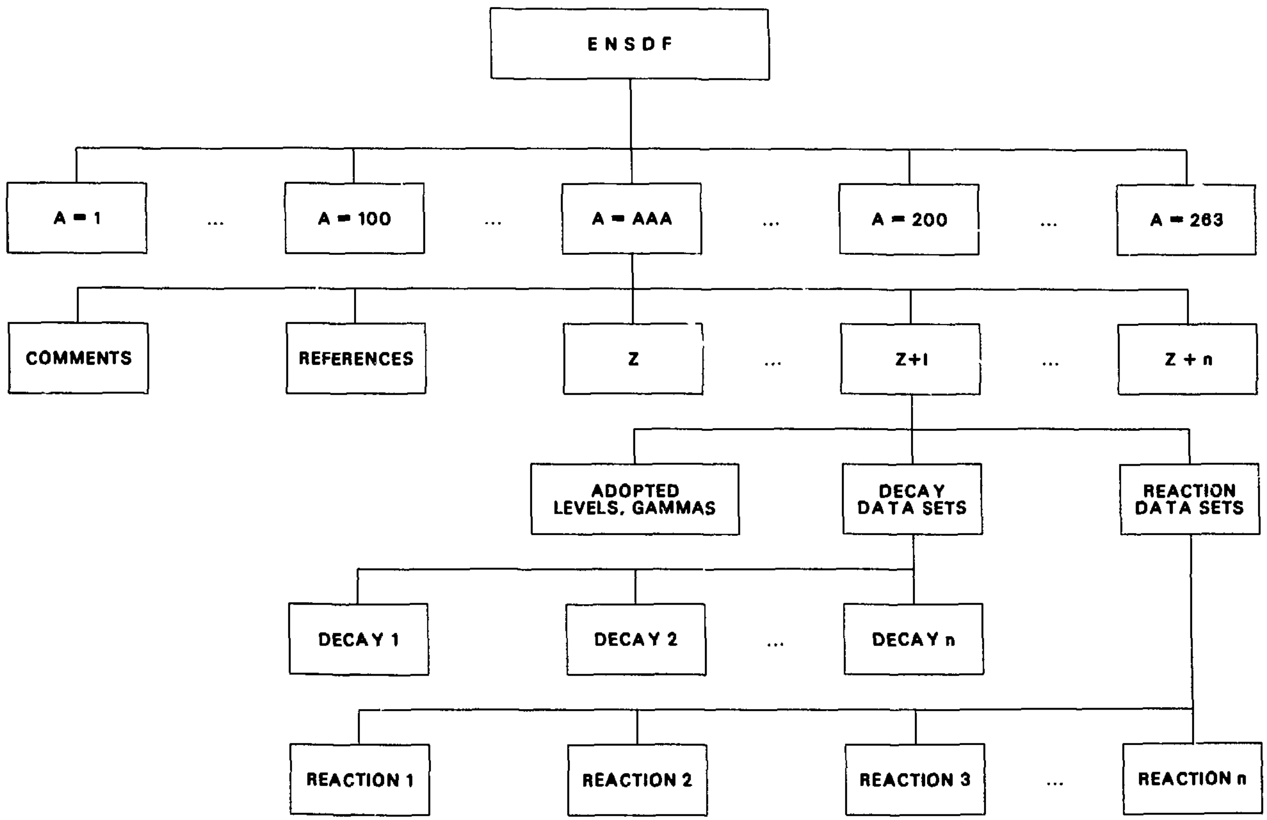


Fig. 1

B. Data Set Structure

A data set is composed of records; each record is made up of one or more card images. Data set structure is given in Fig. 2 and is described below:

A data set *must* begin with an **IDENTIFICATION** record and *must* end with an **END** record (a blank card). Between these two records, there can be as many additional records as are needed to describe fully the experimental or the evaluated data.

Immediately following the **IDENTIFICATION** record is a group of records which contain information about the entire data set (#1 and #2 in Fig. 2). The general **COMMENT (C)**, **NORMALIZATION (N)**, **Q-VALUE (Q)**, and **PARENT (P)** records are of this type. Not all of these records are included in every data set.

The body of a data set (#3 and #4 in Fig. 2) is composed of numeric data records which describe the measured or deduced properties of levels, γ rays, α particles, etc. These records are associated with the level which decays (for **GAMMA** records) or the level which is populated (for **BETA**, **EC**, or **ALPHA** records). Thus, each **LEVEL** record is followed by a group of records describing charged-particle decay into the level and γ-ray decay out of the level (#4 in Fig. 2).

If a **GAMMA** record (or **ALPHA**, or **EC**, or **BETA**) properly belongs in a data set but cannot be associated with any particular level, then the record should be placed in the data set *before any* **LEVEL** records (#3 in Fig. 2).

The placement of **COMMENT** records is described in Chapter III.

C. File Storage and Transmittal

The data sets sent to NNDC for inclusion in ENSDF can be in any order, as the file is stored in a random access mode (by data sets) using a data base management system. Copies of the file are transmitted in the form of a sequential file on magnetic tape. The data sets in the sequential file are arranged by mass numbers in increasing numerical order. For a given mass number the data sets are organized as given in Fig. 1, ordering them from left to right. Decay data sets are placed under the daughter nucleus and are ordered by A, Z and then the excitation energy of the parent nucleus. The reaction data sets are given under the residual nucleus and are ordered by the A, Z of the target nucleus follwed by the A, Z of the incident particle and then by the energy of the incident particle.

II. General Organization

Data Set Structure

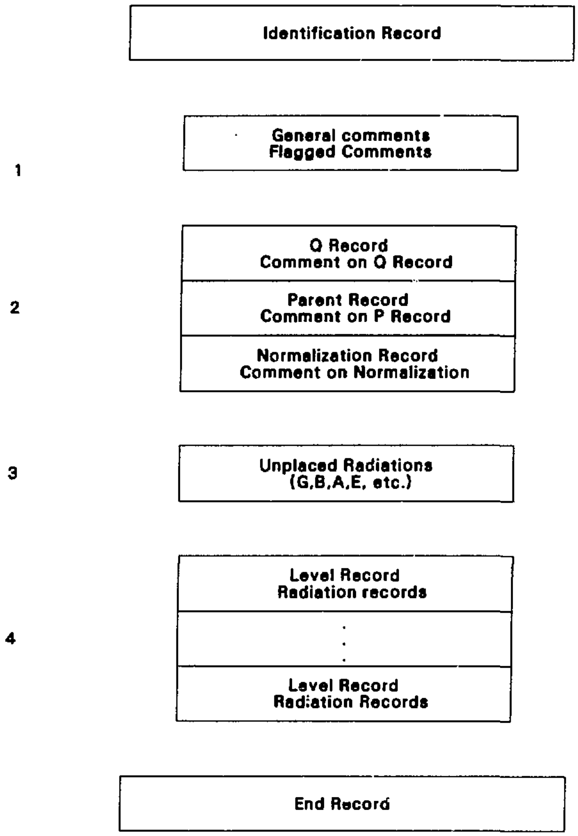


Fig. 2

III. STANDARD ONE-CARD RECORD FORMATS

A. Introduction

In most cases, all information for a record can be placed on a single 80-column card. A "standard" format has been defined for each one-card record, such that the most commonly used quantities can be placed on a single card. The standard formats are described in this section for each record. If a needed quantity is not included in the standard format or if a value will not fit within the field defined for the value by the standard format, or if a record cannot be contained on a single card, then additional cards can be prepared as described in Chapter IV (for examples, see Appendix A). Note that many of the analysis programs, at present, do not process standard fields when placed on the continuation cards.

B. The Standard One-Card Record Formats

Record formats are given below in the same order in which they would normally be encountered in a data set. Conditions under which each record may appear or be required are given in parentheses. The format descriptions give the fields (in inclusive card-column numbers), the field names (the formal "name" of the quantity that goes into the field), and a brief field description. Card columns not explicitly included in the fields are expected to be blank. A detailed description of each field can be found in the reference section noted. (Any numerical field left blank usually implies that the numerical information is lacking. Numbers will usually be assumed to be positive unless stated otherwise.) Numbers can be entered anywhere in the appropriate field (i.e., there is no need to left-adjust or right-adjust.)

III. Standard One-Card Record Formats

1. THE IDENTIFICATION RECORD

(Required for all data sets. Must precede all other records.)

Field (Col.)	Name	Description	Reference
1-5	NUCID	Nucleus Identification	V.A
6-9		Must be blank	
10-39	DSID	Data set identification	V.B
40-64	DSREF	References to main supporting publications and analyses	V.C
65-74	PUB	Publication Information	V.D
75-80	DATE	The date (year/month/day) when the data set was placed in ENSDF (entered automatically by computer)	V.E

2. THE COMMENT RECORD

i. General Comments

Field (Col.)	Name	Description	Reference
1-5	NUCID	Nucleus identification	V.A
6		Blank or 1. Any other character, e.g., 2,3,..,9,A,B,..,Z, etc., for continuation records	
7	C	Letter "C", "D", or "T" is required *See notes 2 and 3 below*	
8-9		Must be blank	
10-80	CTEXT	Text of the comment. [See ENSDF Translation Dictionary (Appendix B)]	V.G

NOTES:

1. The comment refers to the whole data set. In the case that NUCID contains only the mass number, A, the comment refers to the whole mass-chain A. General comments must be placed in a data set before any **L**, **G**, **B**, **E**, or **A** records.
2. Letter "T" in place of "C" in col. 7 of a comment record indicates to the output programs that this record should be reproduced "as is" and the blanks in the record should not be squeezed out. *See example in Appendix A.*
3. Letter "D" in place of "C" in col. 7 of a comment record indicates to the output programs that this is a documentation record and should be ignored. This record will also be ignored by the various analysis programs.

THE COMMENT RECORD (cont.)

ii. Record Comments and Flagged Comments

Field (Col.)	Name	Description	Reference
1-5	NUCID	Nucleus identification	V.A
6		Blank or 1. Any other character, e.g., 2,3,..,9,A,B,..,Z, etc., for continuation records	
7	C	Letter "C", "D", or "T" is required *See notes 2 and 3 on the preceding page*	
8	RTYPE	Record type being commented upon	V.F
9		Must be blank	
10-19	SYM(FLAG) or SYM,SYM,...	**SYM** = type of data being commented upon **FLAG** = string of characters which *may* be separated by commas. *See notes below*	V.H
20-80	CTEXT	Text of comment On continuation comment records, cols. 10-80 may be used for **CTEXT**, and **SYM** or **SYM(FLAG)** are *not* repeated. [See **ENSDF** Translation Dictionary (Appendix B)]	V.G

NOTES:

1. Record comment placed at the head of the data set
   - This refers to all records of the specified **RTYPE** in the data set.
   - The comment will normally appear only in the table for that **RTYPE** in the output. For example, if the comment is on levels ("L" in col. 8) it will appear only in the level properties table.
   - The comment with **SYM** only (no **FLAG**) in cols. 10-19 will appear as a footnote on the column heading corresponding to the data type specified by **SYM**.
   - When the **FLAG** is also specified then only those data values of data types specified by **SYM** in the records which have one of the characters specified in **FLAG** in their col. 77 will get foot-noted. *See examples in Appendix A.*

2. Flagged comments must be placed *before* any **L**, **G**, **B**, **E** or **A** records.

3. Record comments placed immediately following a record refer only to that one record. (For example, a comment with "L" in col. 8 and "T" in col. 10, placed at the head of a data set, refers to *all* level half-lives in that data set. The same comment placed immediately following the level record for the second-excited state refers *only* to the half-life of the second-excited state.)

4. Comments for which **RTYPE** is **N**, **P**, or **Q** must be placed immediately following those records.

3. THE NORMALIZATION RECORD

*(Must precede **L**, **G**, **B**, **E**, **A** records.*
Required if an absolute normalization is possible, used mainly with decay and (n,γ) reaction data sets.)

Field (Col.)	Name	Description	Reference
1–5	**NUCID**	Nucleus (Daughter/Product) identification	V.A
6		Blank or 1	
7		Must be blank	
8	**N**	Letter "N" is required	
9		Must be blank	
10–19	**NR**	Multiplier for converting relative *photon* intensity (**RI** in the **GAMMA** record) to *photons* per 100 decays of the parent through the decay branch or to *photons* per 100 neutron captures in an (n,γ) reaction. *Required* if the absolute photon intensity can be calculated.	V.I
20–21	**DNR**	Standard uncertainty in **NR**	V.K
22–29	**NT**	Multiplier for converting relative *transition* intensity (including conversion electrons) [**TI** in the **GAMMA** record] to *transitions* per 100 decays of the parent through this decay branch or per 100 neutron captures in an (n,γ) reaction. *Required* if **TI** are given in the **GAMMA** record and the normalization is known.	V.I
30–31	**DNT**	standard uncertainty in **NT**	V.K
32–39	**BR**	Branching ratio multiplier for converting intensity per 100 decays through this decay branch to intensity per 100 decays of the parent nucleus. *Required if known.*	
40–41	**DBR**	Standard uncertainty in **BR**	V.K
42–49	**NB**	Multiplier for converting relative β^- and ϵ intensities (**IB** in the **B–** record; **IB**, **IE**, **TI** in the **EC** record) to intensities per 100 decays through this decay branch. *Required if known.*	V.I
50–55	**DNB**	Standard uncertainty in **NB**	V.K
56–80		Must be blank	

4. THE PARENT RECORD

(Required for all decay data sets, except IT and SF decay. Must precede L, G, B, E, A records.)

Field (Col.)	Name	Description	Reference
1–5	NUCID	Parent Nucleus identification	V.A
6		Blank or 1	
7		Must be blank	
8	P	Letter "P" is required	
9		Must be blank	
10–19	E	Energy of the decaying level in keV (0 for g.s.)	V.R
20–21	DE	Standard uncertainty in E	V.K
22–39	J	Spin and parity	V.T
40–49	T	Half-life; units *must* be given	V.N
50–55	DT	Standard uncertainty in T	V.L
56–64		Must be blank	
65–74	QP	Ground-state Q-value in keV (total energy available for g.s. → g.s. transition); will always be a positive number	V.I
75–76	DQP	Standard uncertainty in QP	V.K
77–80		Must be blank	

5. THE Q-VALUE RECORD

(Required for Adopted Levels and Adopted Levels, Gammas data sets. Must precede L, G, B, E, A records. If signs are not given, they will be assumed to be +.)

Field (Col.)	Name	Description	Reference
1–5	NUCID	Nucleus identification	V.A
6		Blank or 1	
7		Must be blank	
8	Q	Letter "Q" is required	
9		Must be blank	
10–19	Q^-	Total energy (keV) available for β^- decay of the ground state. ($Q^- > 0$ if β^- decay is energetically possible. $Q^- < 0$ represents the Q_ε energy of the Z+1 (Z = proton number) isobar.)	V.J
20–21	DQ^-	Standard uncertainty in Q^-	V.K
22–29	SN	Neutron separation energy in keV	V.J
30–31	DSN	Standard uncertainty in SN	V.K
32–39	SP	Proton separation energy in keV	V.J
40–41	DSP	Standard uncertainty in SP	V.K
42–49	QA	Total energy (keV) available for α decay of the ground state	V.J
50–55	DQA	Standard uncertainty in QA	V.K
56–80	QREF	Reference citation(s) for the Q-values	V.C

6. THE LEVEL RECORD

(Optional, although a data set usually has at least one.)

Field (Col.)	Name	Description	Reference
1-5	NUCID	Nucleus identification	V.A
6		Blank or *1* Any other character, e.g., 2,3,..,9,A,B,..,Z, etc., for continuation records	
7		Must be blank	
8	L	Letter "L" is required	
9		Must be blank	
10-19	E	Level energy in keV	V.R
20-21	DE	Standard uncertainty in **E**	V.K
22-39	J	Spin and parity	V.T
40-49	T	Half-life of the level; units *must* be given. Mean-life expressed as the width of a level, in units of energy, may also be used	V.N
50-55	DT	Standard uncertainty in **T**	V.L
56-64	L	Angular momentum transfer in the reaction determining he data set. (Whether it is L_n, L_p, ΔL, etc., is determined from the **DSID** field of the **IDENTIFICATION** record.)	V.V
65-74	S	Spectroscopic strength for this level as determined from the reaction in the **IDENTIFICATION** record. (Spectroscopic factor for particle-exchange reactions; β for inelastic scattering.)	V.U
75-76	DS	Standard uncertainty in **S**	V.K
77	C	Comment **FLAG** used to refer to a particular comment record	V.H
78-79	MS	Metastable state is denoted by "M " or "M1" for the first (lowest energy) isomer; "M2", for the second isomer, etc.	V.Q
80	Q	The character "?" denotes an uncertain or questionable level Letter 'S" denotes neutron or proton separation energy	

7. THE GAMMA RECORD

*(Must follow the **LEVEL** record for the level from which the γ ray decays. Records for γ rays which are unassigned in a level scheme should precede the first level of the data set.)*

Field (Col.)	Name	Description	Reference
1–5	NUCID	Nucleus identification	V.A
6		Blank or 1 Any other character, e.g., 2,3,..,9,A,B,..,Z, etc., for continuation records	
7		Must be blank	
8	G	Letter "G" is required	
9		Must be blank	
10–19	E	Energy of the γ-ray photon in keV	V.R
20–21	DE	Standard uncertainty in E	V.K
22–29	RI	Relative photon intensity†	V.M
30–31	DRI	Standard uncertainty in RI	V.K
32–41	M	Multipolarity of transition	V.S
42–49	MR	Mixing ratio, δ. (Sign must be shown explicitly if known. If no sign is given, it will be assumed to be unknown.)	V.J
50–55	DMR	Standard uncertainty in MR	V.L
56–62	CC	Total conversion coefficient	V.I
63–64	DCC	Standard uncertainty in CC	V.K
65–74	TI	Relative total transition intensity†	V.M
75–76	DTI	Standard uncertainty in TI	V.K
77	C	Comment FLAG used to refer to a particular comment record. The character * denotes a multiply placed γ ray	V.H
78	ORG	Letter "C" denotes coincidence with a preceding radiation	V.O
79	END	Letter "C" denotes coincidence with a following radiation	V.O
80	Q	The character "?" denotes an uncertain placement of the transition in the level scheme Letter "S" denotes an expected, but as yet unobserved, transition	

†The intensity units are defined by the **NORMALIZATION** record.

8. THE BETA (β^-) RECORD

*(Must follow the **LEVEL** record for the level which is fed by the β^-.)*

Field (Col.)	Name	Description	Reference
1-5	NUCID	Nucleus identification	V.A
6		Blank or 1 Any other character, e.g., 2,3,..,9,A,B,..,Z, etc., for continuation records	
7		Must be blank	
8	B	Letter "B" is required	
9		Must be blank	
10-19	E	Endpoint energy of the β^- in keV *Given only if measured*	V.R
20-21	DE	Standard uncertainty in **E**	V.K
22-29	IB	Intensity of the β^- decay branch†	V.M
30-31	DIB	Standard uncertainty in **IB**	V.K
42-49	LOGFT	The log *ft* for the β^- transition for uniqueness given in col. 78-79	V.I
50-55	DFT	Standard uncertainty in **LOGFT**	V.L
56-76		Must be blank	
77	C	Comment **FLAG** (Letter "C" denotes coincidence with a following radiation.)	V.H
78-79	UN	Uniqueness classification for the β^- decay, e.g., "1U", "2U". (A blank signifies an allowed or a nonunique forbidden transition.)	V.P
80	Q	The character "?" denotes an uncertain or questionable β^- decay Letter "S" denotes an expected or predicted transition	

†The intensity units are defined by the **NORMALIZATION** record.

9. THE EC (or EC + β^+) RECORD

*(Must follow the **LEVEL** record for the level being populated in the decay.)*

Field (Col.)	Name	Description	Reference
1–5	NUCID	Nucleus identification	V.A
6		Blank or 1 Any other character, e.g., 2,3,..,9,A,B,..,Z, etc., for continuation records	
7		Must be blank	
8	E	Letter "E" is required	
9		Must be blank	
10–19	E	Energy for *electron capture* to the level *Given only if measured*	V.R
20–21	DE	Standard uncertainty in E	V.K
22–29	IB	Intensity of β^+-decay branch†	V.M
30–31	DIB	Standard uncertainty in IB	V.K
32–39	IE	Intensity of electron capture branch†	V.M
40–41	DIE	Standard uncertainty in IE	V.K
42–49	LOGFT	The log *ft* for (ϵ + β^+) transition for uniqueness given in col. 78–79	V.I
50–55	DFT	Standard uncertainty in LOGFT	V.L
65–74	TI	Total (ϵ + β^+) decay intensity†	V.M
75–76	DTI	Standard uncertainty in TI	V.K
77	C	Comment **FLAG** (Letter "C" denotes coincidence with a following radiation.)	V.H
78–79	UN	Uniqueness classification for ϵ, β^+ decay. e.g., "1U", "2U". (A blank signifies an allowed or a nonunique forbidden transition.)	V.P
80	Q	The character "?" denotes an uncertain or questionable ϵ, β^+ branch Letter "S" denotes an expected or predicted transition	

†**IE**, **IB** and **TI** must be in the same units (see also **NB** in **NORMALIZATION** record).

10. THE ALPHA RECORD

*(Must follow the **LEVEL** record for the level being populated in the decay.)*

Field (Col.)	Name	Description	Reference
1-5	**NUCID**	Nucleus identification	V.A
6		Blank or 1	
7		Must be blank	
8	**A**	Letter "A" is required	
9		Must be blank	
10-19	**E**	Alpha energy in keV	V.R
20-21	**DE**	Standard uncertainty in **E**	V.K
22-29	**IA**	Intensity of α-decay branch in *percent* of the total α decay	V.M
30-31	**DIA**	Standard uncertainty in **IA**	V.K
32-39	**HF**	Hindrance factor for α decay	V.I
40-41	**DHF**	Standard uncertainty in **HF**	V.L
42-76		Must be blank	
77	**C**	Comment **FLAG** (Letter "C" denotes coincidence with a following radiation.)	V.H
78-79		Must be blank	
80	**Q**	The character "?" denotes uncertain or questionable α branch Letter "S" denotes an expected or predicted α branch	

11. THE REFERENCE RECORD

(Record can occur only in Reference data set. NNDC provides the Reference data set)

Field (Col.)	Name	Description	Reference
1-3	**MASS**	Mass Number	
4-7		Must be blank	
8	**R**	Letter "R" is required	
9		Must be blank	
10-15	**KEYNUM**	Reference key number	V.C
16-80	**REFERENCE**	Abbreviated reference (from NSR file)	

12. THE END RECORD

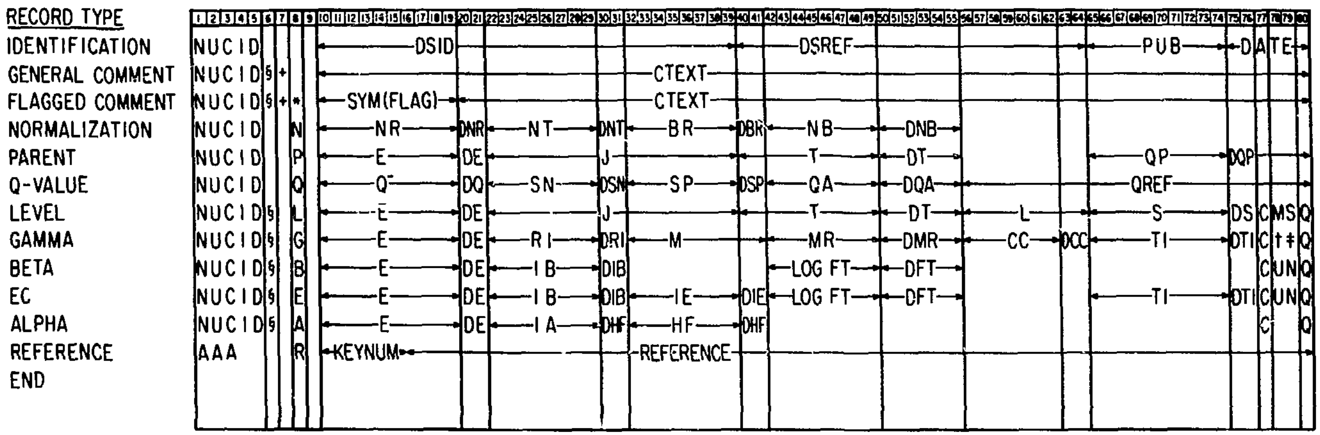
(Required for all data sets. Must be the last record in a data set.)

Field (Col.)	Description
1-80	All columns are blank

C. Summary

The following figure (Fig. 3) summarizes the standard one-card formats for all allowed record types.

SUMMARY
ENSDF STANDARD ONE-CARD FORMATS



* = RTYPE

§ = COLUMN 6 IS BLANK OR 1 FOR THE FIRST CARD RECORD, ANY OTHER CHARACTER FOR CONTINUATION

† = ORG

‡ = END

+ = "C" OR "D" OR "T"

AAA = MASS NUMBER

Fig. 3

IV. RECORDS CONTAINING MORE THAN ONE CARD

A. Card Enumeration

If all the information for a given record type cannot be contained on a single card, it is possible to use additional cards to describe the record fully. The first card of a record will have a blank or number 1 in col. 6. Subsequent cards will have characters different from blank or 1 (usually running numbers: 2 to 9 or letters A to Z). The continuation cards are allowed only for **LEVEL**, **GAMMA**, **B–**, and **EC** records.

B. Format for Continuation Cards

THE CONTINUATION RECORD

*(Must follow the record of the same **RTYPE**.)*

Field (Col.)	Name	Description
1–5	**NUCID**	Nucleus identification
6		Any character other than blank, 0 or 1; usually, 2,3,..9,A,B,..Z
7		Must be blank
8	**RTYPE**	Letter corresponding to the record type **L**, **B**, **E** or **G**
9		Must be blank
10–80	**Text**	<quant><op><value>[<op><value>][<ref>]**$** ...

In the description of **Text** above the following abbreviations have been used:

<quant>: Standard symbol for a quantity as defined in **IV.C** below.
Note: Ratios of more than two quantities should be indicated by colons and not by slashes (e.g., K:L1:L2:L3 and not K/L1/L2/L3).

<op>: =, <, >, EQ, AP, LT, LE, GT, GE
Note: For the last 6 operators blanks before and after them are required.

<value>: Numeric value with units as needed and optional uncertainty. Uncertainty is as defined in Sections **V.K** and **V.L**.
Note: For ranges, uncertainties should not be included. To specify a bounded range of values a second operator and value are required – see examples below.

[]: Optional.

<ref>: 6 character key numbers, **KEYNUM** (see **V.C**), separated by commas and enclosed within parentheses, e.g., (76TU01,81BO01).

$**: Delimiter (end of record is also a delimiter; thus '**$' should not be the last character in a record)

Examples:

```
126TE2 G BE2W=25.3 7(70LAZM)
126I  2 L %EC+%B+=56.3 20 (77JA04)$%B- EQ 43.7 20 (77JA04)
126SN2 B EAV=2030 60
126TE2 L G LE 0.19 GT 0.1 (81SH15)$MOME2 AP -0.20$BE2=0.478 12
```

C. ALLOWED DATA TYPES ON CONTINUATION RECORDS

Each record type is permitted to contain only a limited (but extendable) set of data types. For example, a **GAMMA** record is not allowed to contain information of data type **DTYPE** = **J** (nuclear spin). Neither may a **LEVEL** record contain **LOGFT** information. For each record type, the following table lists the data type permitted as of March 1983.

1. The PARENT Record

All allowed data types are included in the standard format description in Section **III.B.4**

2. The Q-VALUE Record

All allowed data types are included in the standard format description in Section **III.B.5**

3. The LEVEL Record

Allowed data types **E**, **DE**, **J**, **T**, **DT**, **L**, **S**, **DS**, **C**, **MS**, **Q**, are described with the standard formats in Section **III.B.6**. Additional allowed data types are:

TYPE	Description
%EC, **%B+**, **%EC+%B+**, **%B-**, **%IT**, **%SF**, **%A**, **%P**, **%N**	Percent decay of the level by ε, β^+, $\varepsilon+\beta^+$, β^-, isomeric transition, spontaneous fission, α, proton, or neutron decay.
G	g-factor of the level
MOME1, **MOME2**, ...	Electric moments: dipole, quadrupole, ...
MOMM1, **MOMM2**, ...	Magnetic moments: dipole, quadrupole, ...
CONF	Nuclear configuration of the level
BE1, **BE2**, ...	Reduced electric transition probability (*upward*) given in units $e^2 \times (\text{barns})^L$, where L = 1, 2, ... for the transition from the ground state to this level
ISPIN	Isobaric spin

4. The GAMMA Record

Allowed data types, **E**, **DE**, **RI**, **DRI**, **M**, **MR**, **DMR**, **CC**, **DCC**, **TI**, **DTI**, **C**, **ORG**, **END**, **Q**, are described with the standard formats in Section **III.B.7**. Additional allowed data types are:

DTYPE	Description
BE1, **BE2**, ...	Reduced electric transition probability (*downward*) given in units of $e^2 \times (\text{barns})^L$, where L = 1, 2, ...
BE1W, **BE2W**, ...	Reduced electric transition probability (*downward*) given in single-particle (Weisskopf) units
BM1, **BM2**, ...	Reduced magnetic transition probability (*downward*) given in units of $\mu^2_N \times (\text{barns})^{L-1}$, where L = 1, 2, ...

GAMMA Record (continued)

DTYPE	Description
BM1W, BM2W, ...	Reduced magnetic transition probability (*downward*) given in single-particle (Weisskopf) units
CEK, CEL, CEL1, ...	Conversion-electron (ce) intensity for K, L, L_1, ... conversion
KC, LC, L1C, ...	Theoretical K–, L–, L_1–,... conversion coefficient
EKC, ELC, EL1C, ...	Measured K–, L–, L_1–,... conversion coefficient
K/L, M/L, L1/L2, ...	Conversion-electron intensity ratios
K/T, L/T, ...	Ratio of K, L, ... ce-intensity to total (γ + ce) intensity

5. The BETA (B^-) Record

Allowed data types **E**, **DE**, **IB**, **DIB**, **LOGFT**, **DFT**, **COIN**, **UN**, **Q**, are described with the standard formats in Section **III.B.8**. Additional allowed data types are:

DTYPE	Description
EAV	Average energy of the β^- spectrum

6. The EC Record

Allowed data types, **E**, **DE**, **IB**, **DIB**, **IE**, **DIE**, **LOGFT**, **DFT**, **TI**, **DTI**, **C**, **UN**, **Q**, are described with the standard formats in Section **III.B.9**. Additional allowed data types are:

DTYPE	Description
EAV	Average energy of the β^+ spectrum
CK, CL, CM, CN+	Fraction of decay by electron capture from the K, L, M, N+O+... shells (**K**, **L**, **M**, **N+** are also acceptable as **DTYPE** and have the same meaning.)

7. The ALPHA Record

All allowed data types are included in the standard format description in **Section III.B.10**.

V. DETAILED FIELD DESCRIPTIONS

A. NUCID

The standard nucleus identification consists of two parts – mass number in cols. (1–3), right justified and element name (or Z–100 for Z>103) in (col. 4–5), left justified. The nucleus identification must be contained *within* the field defined for it (cols. 1–5). The nucleus identification *must* be included on every **IDENTIFICATION** record. It must also be included on every card of a data set except the **END** record. Comments and reference data sets pertaining to the whole A–(mass) chain evaluation contain only the A–value in the **NUCID** field.

B. DSID

The Data Set **ID** for an ENSDF data set must serve as a unique, computer recognizable identification for the data set. For that purpose, the following rules should be strictly observed for ENSDF entries. Single blanks have meaning and should be used according to the formats below. A colon may be used to define a sub-topic. All characters must be confined to the 30 spaces allowed. *Optional fields are given in italics.* General categories are given in upper and lower cases and further defined.

GENERAL ID'S

REFERENCES (1)
COMMENTS
ADOPTED LEVELS
ADOPTED LEVELS, GAMMAS

DECAY DATA SET ID'S

Parent Mode Decay (*Half–life units*) (2)

Parent should be the parent isotope symbol (e.g.) 52CR.
Mode may be one of **B+**, **B–**, **EC**, **IT**, **A**, or **SF**.
Half–life can be of the form NUM defined in **V.I**.
Units are required if Half–life is given. Units can be one of the following:
Y, D, M, S, MS, US, NS, PS, FS, AS, EV, KEV, or MEV *(See also V.N)*

MUONIC ATOM (3)

REACTION DATA SET ID'S

Target(Reaction), (*Reaction*), *Target*(*Reaction*) *E=Energy Qualifier* (4)
COULOMB EXCITATION (*Reaction*) (5)
INELASTIC SCATTERING
(HI,XNG)

Target should be the target (isotope or element) symbol
Reaction should be a reaction symbol (e.g.) **N**, **P**.

REACTION DATA SET ID'S (CONT.)

Energy may be one of the following

NUM, *NUM* Units (for definition of NUM see **V.I.**)
NUM-NUM Units
THERMAL or TH
RESONANCE or RES

Qualifier may be one of the following

RES
IAR
IAS

EXAMPLES:

187RE B- DECAY
187OS IT DECAY (231 US)
187AU A DECAY:?
190PT A DECAY (6E11 Y)
186OS(N,G) E=THERMAL
186W(N,G) E=TH: SECONDARY G'S
RE(N,N'):TOF
186W(N,G) E=RES: AVG
189OS(P,T) E=19 MEV
187OS(D,D') E=12, 17 MEV
185RE(A,2NG) E=23-42.8 MEV
187RE(D,2NG), 187RE(P,NG)
44CA(P,G) E=856, 906 KEV IAR

C. DSREF, KEYNUM, QREF

The **DSREF** and **QREF** fields may include up to three key numbers (**KEYNUM**) each of which refers to a particular publication. Additional key numbers may be placed in **COMMENT** records. *Key numbers must be left-justified and separated by commas with no blanks between the comma and the reference.* A reference key number must be of the form **YYAABB** where **YY** is a two digit integer, **AA** are two alphabetic characters and **BB** is either a two digit integer or consists of two alphabetic characters. Examples: **81TU01**, **81TUXY**, etc.

D. PUB

Publication information consists of the year of the A-chain publication in Nuclear Data Sheets denoted by two digit year indicator followed by three-character code **NDS**. This may optionally be followed by a comma and the initials of the persons modifying the data set after its publication. Example **78NDS,WBE** or **81NDS**.

E. DATE

This field is of the form **YYMMDD** where **YY**, **MM** and **DD** are two digit integers within the following ranges **00 ≤ YY ≤ 99**, **01 ≤ MM ≤ 12** and **01 ≤ DD ≤ 31**.

F. RTYPE

RTYPE is a single-letter code in col. 8 that gives a name to the **RECORD** type.

RTYPE	**Description**
Blank	May be **IDENTIFICATION** record, general **COMMENT** record, or **END** record
N	**NORMALIZATION** record
P	**PARENT** record
Q	**Q-VALUE** record
L	**LEVEL** record
G	**GAMMA** record
B	**BETA** (B^-)record
E	**EC** (or **EC** + B^+) record
A	**ALPHA** record
R	**REFERENCE**

G. CTEXT

This field consists of free text. The various expressions used in **CTEXT** can be translated via dictionary lookup. The translation dictionary is given in Appendix B. The unit expression used in translation is the string of characters between adjacent "delimiters". The characters presently used as "delimiters: are:

b(blank) ,(comma) .b(period followed by a blank) ; : ( ) - = + < > / and **$**

In some cases the dictionary lookup programs look beyond the next delimiter for proper translation.

H. SYM(FLAG)

The **SYM(FLAG)** field (with **FLAG** given) is valid only for records with **RTYPE**: **L**, **G**, **B**, **E**, **A**.
However, **SYM** (without **FLAG**) may be used for records with **RTYPE**: **L**, **G**, **B**, **E**, **A**, **N**, **P**, **Q**.

FLAG can be a string of characters *optionally* separated by commas. Any character other than a comma and parentheses can be used as a **FLAG** symbol. For **B** and **E** records "C" can not be used for a **FLAG** as "C" in column 77 of **B**, **E** AND **A** records denotes coincidence. Similarly "*" for **G** records is reserved to denote multiple placement in the level/decay scheme.

H. SYM(FLAG) (CONT.)

Allowed symbols to be used as **SYM** for various **RTYPE** are given below:

RTYPE	Allowed **SYM**
L	E, DE, J, T, DT, L, S, DS, BAND, CONF, BE1, BE2, ..., G, ISPIN, MOME1, MOME2, ..., MOMM1, MOMM2, ..., %EC+%B+, %X (X=B-, B+, EC, IT, SF, A, P, or N)
G	E, DE, RI, DRI, M, MR, DMR, CC, DCC, TI, DTI, BE1, BE2, ..., BE1W, BE2W, ..., BM1, BM2, ..., BM1W, BM2W, ..., CEK, CEL, CEL1, ..., KC, LC, L1C, ..., EKC, ELC, EL1C, ..., K/L, M/L, L1/L2, ..., K/T, L/T, ...
B	E, DE, IB, DIB, LOGFT, DFT, EAV
E	E, DE, IB, DIB, IE, DIE, LOGFT, DFT, TI, DTI, EAV, CK, CL, CM, CN+
A	E, DE, IA, DIA, HF, DHF
N	NR, DNR, NT, DNT, BR, DBR, NB, DNB
P	E, DE, J, T, DT, QP, DQP
Q	Q-, DQ-, SN, DSN, SP, DSP, QA, DQA

I. CC, NR, NT, BR, NB, QP, LOGFT, HF

These fields consist of either a blank or a single unsigned number (NUM) in one of the following forms:

1. An integer (e.g., 345)

2. A real number (e.g., 345.23)

3. An integer followed by an integer exponent (e.g., 345E-4, 4E5)

4. A real number followed by an integer exponent (e.g., 345.E-4)

Note: It is desirable to write a number as '0.345' rather than '.345'. However, even if the leading '0' were omitted, presumably to save space, it will appear with a leading '0' in the NDS output.

J. Q–, SN, SP, QA, MR

These fields have the same form as the quantities in **V.I.** above with the difference that they are allowed to be negative as well.

K. DNR, DNT, DBR, DNB, DQP, DQ–, DSN, DSP, DQA, DE, DRI, DTI, DIB, DIE, DCC, DIA, DS

These one or two character fields, represent uncertainty in the "standard" form in the given quantity. The "standard" numeric uncertainty denotes an uncertainty in the last significant figure(s), for example, NR=0.873, DNR=11 represent a normalization factor of 0.873±0.011, similarly QP=2.3E6, DQP=10 stand for a Q-value of $(2.3 \pm 1.0) \times 10^6$ (see also Appendix D-1). The non-numeric uncertainty, e.g. <, >, or ≥, etc. is denoted by expressions LT, GT, and GE, etc.

The allowed forms for these fields are summarized below:

1. Blank
2. An integer ≤99, preferably ≤25, (left or right justified)
3. One of the following expressions:

   LT, GT, LE, GE, AP, CA, SY

   for less than, greater than, less than or equal to greater than or equal to, approximately equal to, calculated, and from systematics, respectively.

L. DFT, DHF, DMR, DT

These fields allow for the specification of "standard" asymmetric uncertainty. For example, T=4.2 S DT=+8-10, represent a half-life $=4.2^{+0.8}_{-1.0}$ s, similarly MR=-3 DMR=+1-4 represent mixing ratio$=-3^{+1}_{-4}$ meaning a range from -7 to -2. (Note: asymmetric uncertainties add algebraically.) When the +/- construction is missing from this field, the digits or the expressions given in this field represent either the numeric "standard" symmetric or the non-numeric uncertainty as described in **V.K.** above.

To summarize this field, there are two cases:

1. Symmetric uncertainty – the field consists of an integer number or an expression of the type described in **K.** above.
2. Asymmetric uncertainty – the field is of the form

   +x-y, where x and y are integers.

V. Detailed Field Descriptions

M. RI, TI, IB, IE, IA

The following numbers/expressions are valid for these fields:

1. NUM (number as defined in I. above)

2. (NUM)

Note: Parentheses denote that the number given has been deduced (not directly measured) or taken from other experiment(s).

N. T

The field for half-life **T** must have one of the following forms:

1. NUM-Blank-Units (i.e. number as defined in **V.I.** above followed by a blank and its units)

   Valid symbols for units are:

   Y, D, M, S, MS, US, NS, PS, FS, AS, EV, KEV, and MEV

   for year, day, minute, second(s), 10^{-3} s, 10^{-6} s, 10^{-9} s, 10^{-12} s, 10^{-15} s, 10^{-18} s, eV, 10^{3} eV, and 10^{6} eV, respectively.

2. Word "STABLE"

Note:A question mark following half-life denotes that the assignment to that level is not certain. A comment should be given to explain the exact meaning intended.

O. ORG, END

These one character fields can either be blank or have character "C" to denote coincidence.

P. UN

This two character field can either be blank or have an integer between 1 and 9 followed by character "U".

Q. MS

This two character field can either be blank or have character "M" followed by a blank or a digit between 1 and 9.

V. Detailed Field Descriptions

R. E

An energy field, **E**, can have only one of the following forms:

1. NUM (as defined in **V.I.** above)
2. NUM+A or A+NUM, where A=X, Y, Z, U, V, or W used in this order; i.e., for the first occurrence an 'X' is used, for its second occurrence a 'Y' is used, and so on.
3. NUM+NUM
4. A (as defined in 2.)

Note: Parentheses are allowed for this field. They denote that the number given has been deduced (not directly measured) or taken from other experiment(s). Any other interpretation should be explained.

S. M

The multipolarity field can be one of the following:

1. Mult
2. Mult+Mult
3. Mult,Mult
4. NOT Mult
5. IF Mult

Where Mult = E_L or $M_{L'}$ (where L, L' are single digits – L ≥0, L' ≥1) or
$M_{L'}+E_L$ or
$E_L+M_{L'}$ or
D or Q

Note: Parentheses in the multipolarity field denote that the assignment is probable and not definite.

V. Detailed Field Descriptions

T. J

The spin-parity field can have only one of the following forms:

1. JPI

2. JPI OR JPI (',' (comma) can be used in place of 'OR')

3. JPI AND JPI ('&' (ampersand) can be used in place of 'AND')

4. JPI TO JPI (':' (colon) can be used in place of 'TO')

   Note: If parity is given in the range it will be interpreted as follows:

a.	J	to J'PI	means	J≤J≤J' and π=PI
b.	JPI	to J'PI'	means	JPI,J=J+1 PI=±,...,J=J'−1 PI=±,J'PI'
c.	JPI	to J'	means	JPI,J=J+1 PI=±,...,J=J'−1 PI=±,J' PI=±

   Examples:

a.	3	to 6−	means	Jπ=3−,4−,5−,6−
b.	3+	to 6−	means	Jπ=3+,4±,5±,6−
c.	3+	to 6	means	Jπ=3+,4±,5±,6±

5. OP JPI where OP ≡ <, LT, LE, >, GT, GE

   Note: This will be interpreted as π=PI and J is OP J
   Example: <5+ means π=+ and J<5

6. NOT JPI

7. NATURAL/UNNATURAL

In the above J = N or N/2 (N is a positive integer)
PI = + or −
JPI = J or PI or J followed by PI

Note:
1. Parentheses in the J^π field indicate that the parenthesised value(s) is (are) based upon weak arguments. See "Bases for Spin and Parity Assignments" − Appendix D-4. Note that JPI=(3,4)− is interpreted as J=(3) or (4) and π=−.
2. As far as possible do not give more than three JPI values.
3. The ranges such as 3− to 5+ are better written as 3−,4,5+.

U. S

This field may contain no more than three S-values, in the form of NUM defined in **V.I**, separated by commas for corresponding L-values given in the L-field (col. 65-74).

V. L

This field may contain no more than three integer numbers (with or without parentheses) separated by commas. Parentheses will be interpreted to mean probable but not definite values.

APPENDIX A

EXAMPLES OF INPUT/OUTPUT IN ENSDF/Nuclear Data Sheets

APPENDIX A-1

ENSDF INPUT

```
205TL    205HG B- DECAY                 71XY01                    EXAMPLE  830201
205HG C  THIS IS A GENERAL COMMENT AND PERTAINS TO COMPLETE DATA SET.
205HG CG           THIS IS A GENERAL COMMENT ON ALL GAMMA RAYS IN THIS SET.
205HG CG E         THIS IS A FOOTNOTE ON EG. IT REFERS TO ALL G'S.
205HG CG E(A)      THIS FOOTNOTE PERTAINS ONLY TO EG OF 1141G.
205HG D  THIS IA A DOCUMENTATION RECORD AND DOES NOT APPEAR IN OUTPUT.
205HG TG           THIS IS A TABULAR COMMENT AND
205HG2TG            ALL SPACES ARE PRESERVED AND
205HG3TG            NOT SQUEEZED OUT.
205HG CB E,IB      THIS IS A FOOTNOTE ON BOTH EB AND IB
205HG  P 0           1/2-              5.2 M     1              1538      8
205TL  N 0.022     10         1
205TL  L 0           1/2+
205TL  B             96      2             5.27115
205TL2 B EAV=     542  4$
205TL CB E         SOME APPROXIMATE MEASUREMENTS LISTED IN 71SC35
205TL  L 203.7       3/2+              1.46 NS   8
205TL CL T         71SH35, 67MA45
205TL  G 203.74    3  100     M1+E2    +1.56   15    0.440
205TL CG E         FROM 72BA53
205TL CG MR        FROM COUL. EX. (73KR02)
205TL CG CC        FROM 73KR02
205TL  B              3.1    13           6.5    2
205TL2 B EAV=     460  4$
205TL1CB IB        ESTIMATED BY 71HI01 TO BE 3.7% 15 BASED ON RATIOS OF
205TL2CB IG(203.7G) TO 197HG,203HG IG'S AND CC(203.7G)=0.62; IB=3.1% IF CC IS
205TL3CB REDUCED TO 0.44
205TL  L 619.3       5/2+
205TL  B             0.016   7             8.6920                           1U
205TL2 B EAV=     299  3$
205TL  G 415.6     3  0.59   8  (M1)                   0.1691
205TL  G 618.6     7  0.090  20
205TL CG           RI(618.6G)/RI(415.6G) IS  AP  TWICE AS LARGE AS IN COUL. EX.
205TL2CG AND (N,N'G)
205TL  L 1140.9     (3/2)+
205TL  B             0.0030 16             7.7424
205TL2 B EAV=     115  3$
205TL  G 937.2     6  0.093  20
205TL  G 1141.1    15 0.045  20                                             A
205TL  L 1218.7      1/2+
205TL  B             0.007   4              7.1 3
205TL2 B EAV=    90.0 25$
205TL  G 1014.7    8  0.031  10
205TL  G 1218.7    4  0.28   5
205TL  L 1340.3     (3/2)+
205TL  B             0.006   3             6.4723
205TL2 B EAV=    53.4 24$
205TL  G 720.6     8  0.051  15
205TL  G 1136.8    6  0.21   5
205TL  G 1340.3    8  0.015  5
205TL  L 1433.9     (1/2,3/2)
205TL  B             0.0049 25             5.6925
205TL2 B EAV=    27.1 22$
205TL  G 1230.8    10 0.023  10
205TL  G 1433.9    5  0.20   5
```

APPENDIX A-2

TABLES OUTPUT

^{205}Tl Levels from ^{205}Hg β− Decay 71Xy01

This is a general comment and pertains to complete data set.

E(level)	Jπ	$T_{1/2}$	Comments
0.0	1/2+		
203.7	3/2+	1.46 ns *8*	$T_{1/2}$: 71Sh35, 67Ma45.
619.3	5/2+		
1140.9	(3/2)+		
1218.7	1/2+		
1340.3	(3/2)+		
1433.9	(1/2,3/2)		

γ(^{205}Tl) from ^{205}Hg β− Decay 71Xy01

This is a general comment and pertains to complete data set.
This is a general comment on all gamma rays in this set.
     This is a tabular comment and
      all spaces are preserved and
      not squeezed out.

Eγ@	E(level)	Iγ†	Mult.	δ	α	Comments
203.74 *3*	203.7	100	M1+E2	+1.56 *15*	0.440	Eγ: from 72Ba53. δ: from Coul. Ex. (73Kr02). α: from 73Kr02.
415.6 *3*	619.3	0.59 *8*	(M1)		0.1691	
618.6 *7*	619.3	0.090 *20*				Iγ(618.6γ)/Iγ(415.6γ) is ≈twice as large as in Coul. ex. and (n,n'γ).
720.8 *8*	1340.3	0.051 *15*				
937.2 *6*	1140.9	0.093 *20*				
1014.7 *8*	1218.7	0.031 *10*				
1136.8 *6*	1340.3	0.21 *5*				
1141.1# *15*	1140.9	0.045 *20*				
1218.7 *4*	1218.7	0.28 *5*				
1230.8 *10*	1433.9	0.023 *10*				
1340.3 *8*	1340.3	0.015 *5*				
1433.9 *5*	1433.9	0.20 *5*				

† For absolute intensity per 100 decays, multiply by 0.022 *10*.
@This is a footnote on Eγ. It refers to all γ's.
#This footnote pertains only to Eγ of 1141γ.

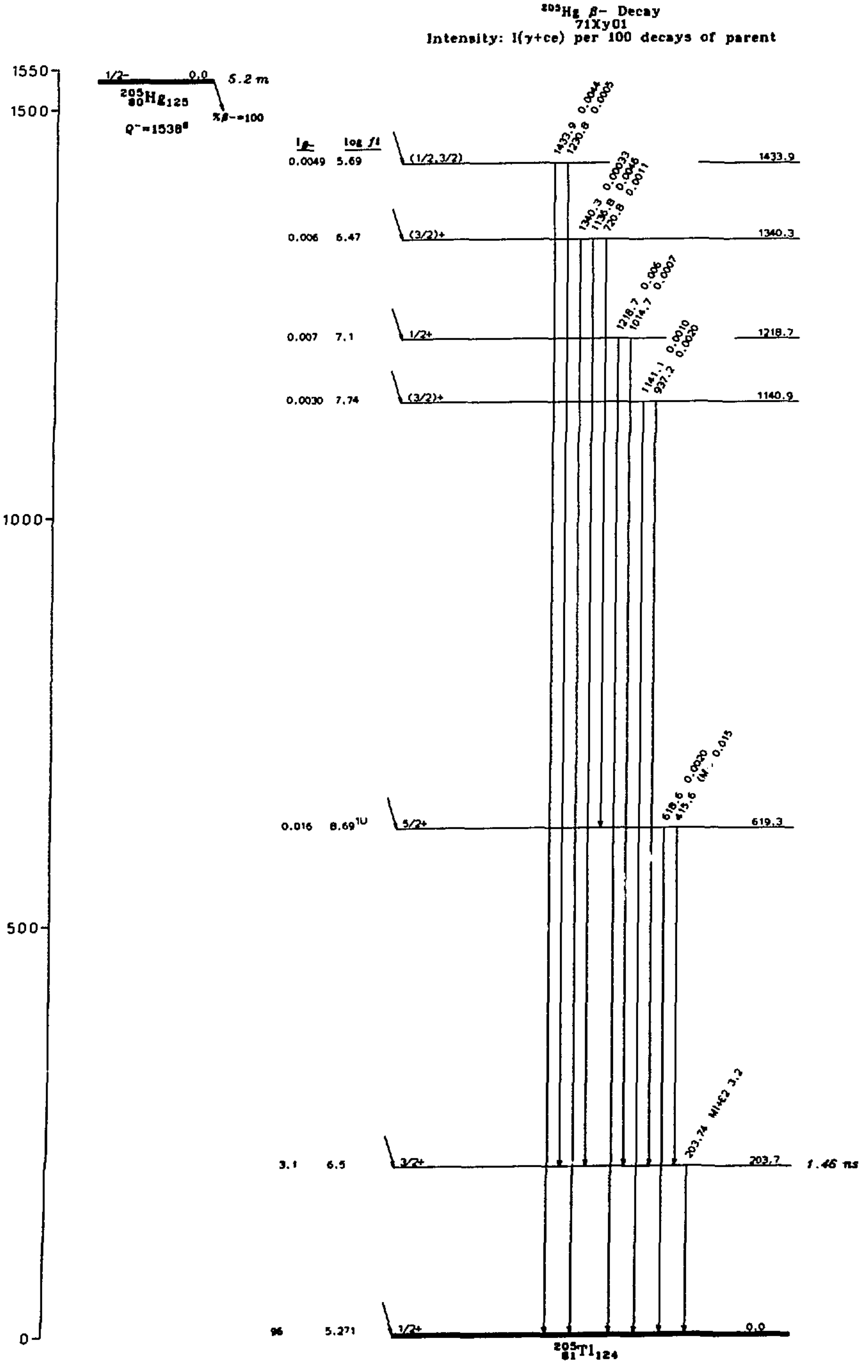
β-radiations from ^{205}Hg β− Decay 71Xy01

This is a general comment and pertains to complete data set.

Eβ−#	E(level)	Iβ−†#	Log *ft*	Comments
(104 *8*)	1433.9	0.0049 *25*	5.69 *25*	avg Eβ=27.1 *22*.
(198 *8*)	1340.3	0.006 *3*	6.47 *23*	avg Eβ=53.4 *24*.
(319 *8*)	1218.7	0.007 *4*	7.1 *3*	avg Eβ=90.0 *25*.
(397 *8*)	1140.9	0.0030 *16*	7.74 *24*	avg Eβ=115 *3*.
(919 *8*)	619.3	0.016 *7*	8.69[1u] *20*	avg Eβ=299 *3*.
(1334 *8*)	203.7	3.1 *13*	6.5 *2*	avg Eβ=460 *4*. Iβ−: estimated by 71Hi01 to be 3.7% *15* based on ratios of Iγ(203.7γ) to ^{197}Hg,^{203}Hg Iγ's and α(203.7γ)=0.62; Iβ=3.1% if α is reduced to 0.44.
(1538 *8*)	0.0	96 *2*	5.271 *15*	avg Eβ=542 *4*. Eβ−: some approximate measurements listed in 71Sc35.

† For β− intensity per 100 decays, multiply by 1.00.
# This is a footnote on both Eβ and Iβ.

APPENDIX A-3
PLOT OUTPUT



APPENDIX B

ENSDF TRANSLATION DICTIONARY

The publication programs translate the text of comments (**CTEXT** in Section **III.B**) from the computer-readable **ENSDF** input into printed output for *Nuclear Data Sheets*.

The translation dictionary, as of February 1983, is given below. The dictionary is constantly enlarged and improved as new needs are encountered.

APPENDIX B (cont.)

ENSDF DICTIONARY

2-Feb-83

ENSDF	TRANSLATION
%A	%α
%B	%β
%DELAYED N	%delayed n
%EC	%ε
%IB	%Iβ
%IT	%IT
%IT-BRANCHING	%IT-branching
%IT-DECAY	%IT-decay
%IT=	%IT=
%M1	%M1
%SF	%SF
(1+CC)	(1+α)
(160,5N)	(^{16}O,5n)
(A)	(α)
(B)	(β)
(B+)	($β^+$)
(B++EC)	(ε+β+)
(B-)	($β^-$)
(BB)	(ββ)
(D,Q)	(D,Q)
(DOWN)	(↓)
(EC+B+)	(ε+β+)
(G)	(γ)
(G0)	($γ_0$)
(H,T)	(H,t)
(IT)	(IT)
(K)	(K)
(L)	(L)
(M)	(M)
(M,N,O+)	(M,N,O+)
(ML)	(ML)
(NE)	(≠)
(023)	(023)
(Q)	(Q)
(T)	(t)
(THETA,H)	(θ,H)
(THETA,H,TEMP)	(θ,H,T)
(UP)	(↑)
*	·
**2	^{2}
*A**(1/3)	·$A^{1/3}$
*G2	g_2
*R	R
*SIGMA	·σ
*T1/2	·$T_{1/2}$
*WIDTH	Γ
1.33LC	1.33α(L)
2J	2J
2MC2	2mc^2
4PI	4π
4PIB	4πβ
4PIBG	4πβγ
A DECAY	α decay
A SYST	α syst
A'	α'
A)	α)
A,	α,
A-N	A-N
A-SYST	α-syst
A/	α/
A0	A_0
A1	A_1
A2	A_2
A3	A_3
A4	A_4
A=	A=
AAS	AAS
ACE	(α)(ce)
AG	αγ
AJ	AJ
ALAGA	Alaga
ALPHA	α
ALPHAS	α's
ANTI-COMPTON	anti-Compton
AP	≈
APRIL	April
AUGER	Auger
AUGUST	August
AUSTERN	Austern
AXK	(α)(K X-ray)
AY	Ay
B	β
B(E1	B(E1
B(E1)	B(E1)
B(E2	B(E2
B(E2)	B(E2)
B(E3	B(E3
B(E3)	B(E3)
B*R	βR
B+	$β^+$
B0	$β_0$
B2	$β_2$
B2*R	$β_2$R
B20	$β_{20}$
B22	$β_{22}$
B3	$β_3$
B3*R	$β_3$R
B30	$β_{30}$
B4	$β_4$
B4*R	$β_4$R
B5	$β_5$
B6	$β_6$
B7	$β_7$
B=	B=
BCE	βce
BCE(T)	βce(t)
BE0	B(E0)
BE1	B(E1)
BE1W	B(E1)(W.u.)
BE2	B(E2)
BE2UP	B(E2)↑
BE2W	B(E2)(W.u.)
BE3	B(E3)
BE3W	B(E3)(W.u.)
BE4	B(E4)
BE4W	B(E4)(W.u.)
BE5	B(E5)
BEL	B(EL)
BELW	B(EL)(W.u.)
BERKELEY	Berkeley
BESSEL	Bessel
BETA	β
BETA(T)	β(t)
BETA*R	βR
BETAS	β's
BF3	BF_3
BG	βγ
BIEDENHARN	Biedenharn
BJ**2	BJ^2
BL	$β_L$

ENSDF DICTIONARY

2-Feb-83

ENSDF	TRANSLATION
BL*R	β_LR
BLAIR	Blair
BM1	B(M1)
BM1W	B(M1)(W.u.)
BM2	B(M2)
BM2W	B(M2)(W.u.)
BM3	B(M3)
BM3W	B(M3)(W.u.)
BM4	B(M4)
BM4W	B(M4)(W.u.)
BO	Bo
BOGOLIUBOV	Bogoliubov
BOHR	Bohr
BORN	Born
BR	Branching
BREIT	Breit
C	C
C.M.	c.m.
C2S	C^2S
CC	α
CCBA	CCBA
CE	ce
CEB	ceβ
CEG	ceγ
CEK	ce(K)
CEL	ce(L)
CEL1	ce(L1)
CEL12	ce(L12)
CEL2	ce(L2)
CEL23	ce(L23)
CEL3	ce(L3)
CEM	ce(M)
CEM1	ce(M1)
CEM2	ce(M2)
CEM3	ce(M3)
CEM4	ce(M4)
CEM45	ce(M45)
CEM5	ce(M5)
CEN	ce(N)
CEN1	ce(N1)
CEN2	ce(N2)
CEN3	ce(N3)
CEN4	ce(N4)
CEN45	ce(N45)
CEN5	ce(N5)
CEO	ce(O)
CEO1	ce(O1)
CERN	CERN
CHI	χ
CHI**2	χ^2
CK	εK
CL	εL
CLEBSCH	Clebsch
CM	εM
CM2	cm^2
CM3	cm^3
COMPTON	Compton
CONF	configuration
CONF=	configuration=
CORIOLIS	Coriolis
COSTER	Coster
COUL	Coul
COULOMB	Coulomb
CP	CP
CURIE	Curie
D)	D)
D+Q	D+Q
DBR	branching uncertainty
DCC	$\Delta\alpha$
DE	ΔE
DECEMBER	December
DEG	
DELTA	Δ
DFT	Δ(log ft)
DHF	Δ(HF)
DIA	$\Delta I\alpha$
DIB	$\Delta I\beta$
DIE	$\Delta I\varepsilon$
DJ	ΔJ
DK	ΔK
DL	ΔL
DMR	$\Delta\delta$
DNR	Δ(γ-normalization)
DOMEGA	dΩ
DOPPLER	Doppler
DPAD	DPAD
DQ+	ΔQ+
DQA	$\Delta Q\alpha$
DRI	$\Delta I\gamma$
DS	ΔS
DS/DW	$d\sigma/d\Omega$
DSA	DSA
DSAM	DSA
DSIGMA	$d\sigma$
DT	$\Delta T_{1/2}$
DT1/2	$\Delta T_{1/2}$
DTI	$\Delta I(\gamma+ce)$
DWBA	DWBA
DWIA	DWIA
DWUCK	DWUCK
E	E
E(A)	E(α)
E(D)	E(d)
E(E)	E(e)
E(N)	E(n)
E(P)	E(p)
E(T)	E(t)
E**1/2	$E^{1/2}$
E+	e+
E-	e-
E.G.	*e.g.*
E/DE	E/ΔE
E0	E0
E1	E1
E1*	E1*
E2	E2
E2*	E2*
E3	E3
E3*	E3*
E4	E4
E4*	E4*
EA	Eα
EAV	avg Eβ
EB	Eβ
EB(	εB(
EC	ε
ECC	α(exp)
ECE	E(ce)
ECK	εK(exp)
ECL	εL(exp)

ENSDF DICTIONARY

2-Feb-83

ENSDF	TRANSLATION
ED	E(d)
EEC	Eε
EG	Eγ
EG**3	$E\gamma^3$
EG**5	$E\gamma^5$
EKC	α(K)exp
EL	EL
EL12C	α(L12)exp
EL1C	α(L1)exp
EL23C	α(L23)exp
EL2C	α(L2)exp
EL3C	α(L3)exp
ELC	α(L)exp
ELC+	α(L+...)exp
EMC	α(M)exp
EMC+	α(M+...)exp
EN	E(n)
ENC	α(N)exp
ENC+	α(N+...)exp
ENDOR	ENDOR
ENGE	Enge
ENSDF	ENSDF
EP	E(p)
EPR	EPR
EPSILON	ε
EPSILONB	εB
ESR	ESR
ET	E(t)
EV	eV
EVEN-A	even-A
EX.	Ex.
F	F
FEBRUARY	February
FERMI	Fermi
FESHBACH	Feshbach
FG	(fragment)γ
FM**2	fm^2
FM-1	fm^{-1}
FOCK	Fock
FOURIER	Fourier
FRENCH	French
FWHM	FWHM
G	γ
G(2+	g(2+
G*T	gT
G*W*WIDTH(0)**2	$gw\Gamma^2(0)$
G*WIDTH	gΓ
G+-	$\gamma^\pm$
G-FACTOR	g-factor
G-FACTORS	g-factors
G-G	γ-γ
G-RADIATIONS	γ-radiations
G.S.	g.s.
G/100	γ/100
G/A	γ/α
G0	γ_0
G1	g_1
G1*WIDTH	$g_1\Gamma$
G2	g_2
G2*WIDTH	$g_2\Gamma$
G=	g=
GALLAGHER	Gallagher
GAMMA	γ
GAMOW	Gamow
GAUSSIAN	Gaussian
GB-	γβ-
GCE	γce
GDR	GDR
GE	≥
GE(LI)	Ge(Li)
GELI	Ge(Li)
GEV	GeV
GG	γγ
GGG	γγγ
GLENDENNING	Glendenning
GORDAN	Gordan
GQR	GQR
GS	g.s.
GT	>
H(	H(
H,	H,
H=	H=
HAGER	Hager
HARTREE	Hartree
HAUSER	Hauser
HF	HF
HI	HI
I	I
I.E.	i.e.
IA	Iα
IAR	IAR
IAS	IAS
IB	Iβ
IB+	Iβ+
IB-	Iβ-
IBA	IBA
IBS	IBS
ICC	α
ICE	Ice
ICE(N)	Ice(N)
IE	Iε
IEC	Iε
IG	Iγ
IMPAC	IMPAC
IN(	In(
IPAC	IPAC
ISOLDE	ISOLDE
ISPIN	T
ISPINZ	T_z
IT DECAY	IT decay
IT DECAYS	IT decays
IT-	IT-
IT=	IT=
J	J
J**2	J^2
J0	J_0
J2	J_2
JANUARY	January
JF	Jf
JI	Ji
JMAX	Jmax
JMIN	Jmin
JOSEF	JOSEF
JPI	Jπ
JULY	July
JUNE	June
K	K
K/L+M	K/L+M
K/T	ce(K)/(γ+ce)
KAPPA	κ

APPENDIX B (cont.)

ENSDF DICTIONARY

2-Feb-83

ENSDF	TRANSLATION
KC	α(K)
KEV	keV
KEVIN	Kelvin
KG	kG
KLL	KLL
KNIGhT	Knight
KPI	Kπ
KRANE	Krane
KRONIG	Kronig
KURIE	Kurie
KUWAIT	Kuwait
KXY	KXY
L	L
L(2N)	L(2n)
L/T	ce(L)/(γ+ce)
L1	L1
L12	L12
L1C	α(L1)
L2	L2
L2C	α(L2)
L3	L3
L3C	α(L3)
LAMBDA	λ
LASER	LASER
LC	α(L)
LE	≤
LEGENDRE	Legendre
LM	LM
LMN	LMN
LN	L(n)
LOG F1T	log $f't$
LOG F1UT	log $f'^{u}t$
LOG FT	log ft
LOGF1T	log $f't$
LOGF1UT	log $f'^{u}t$
LOGFT	log ft
LOHENGRIN	LOHENGRIN
LORENTZIAN	Lorentzian
LP	L(p)
LT	<
M	m
M(	M(
M+=	M+=
M,	M,
M-SHELL	M-shell
M-SUBSHELL	M-subshell
M/T	ce(M)/(γ+ce)
M1	M1
M1*	M1*
M1C	α(M1)
M2	M2
M2*	M2*
M2C	α(M2)
M3	M3
M4	M4
M=	mult=
MAG	magnetic
MARCH	March
MB	mb
MB/SR	mb/sr
MC	α(M)
MC+	α(M+..)
MEDLIST	MEDLIST
MEV	MeV
MEV**-4	MeV^{-4}
MICROBARN	μb
MICROBARNS/SR	μb/sr
ML	M+L
MNO	M+N+O
MOME2	Q
MOMM1	μ
MOSS	Moss
MOSSBAUER	Mossbauer
MOSZKOWSKI	Moszkowski
MR	δ
MR**2	δ^2
MS	ms
MU	μ
N	N
N)	n)
N+/T	ce(N+)/(γ+ce)
N,	n,
N-CAPTURE	n-capture
N-CAPTURES	n-captures
N-RESONANCE	n-resonance
N-RESONANCES	n-resonances
N-SHELL	N-shell
N-SUBSHELL	N-subshell
N-Z	N-Z
N/	N/
N1/N2/N3	N1/N2/N3
N1C	α(N1)
N2C	α(N2)
N3C	α(N3)
N<	N<
N=	N=
NA2WO4	Na_2WO_4
NAI	NaI
NB	β,ε-normalization
NB/SR	nb/sr
NBS	NBS
NC	α(N)
NC+	α(N+..)
NDS	Nuclear Data Sheets
NE	≠
NG	nγ
NGG	nγγ
NILSSON	Nilsson
NMR	NMR
NORDHEIM	Nordheim
NOTE:	Note:
NOVEMBER	November
NQR	NQR
NR	Iγ-normalization
NT	I(γ+ce)-normalization
NU	ν
O	O
OCTOBER	October
ODD-A	odd-A
OMEGA	ω
ORNL	ORNL
OSIRIS	OSIRIS
P	p
P(	P(
P)	p)
P,	p,
P-N	p-n
P-WIDTH	p-width
P0	P_0
P2NG	p2nγ

ENSDF DICTIONARY

2-Feb-83

ENSDF	TRANSLATION
PAC	PAC
PAD	PAD
PC	pc
PG	$p\gamma$
PGG	$p\gamma\gamma$
PHI	Φ
PI	π
PNG	$pn\gamma$
PRI	$\Delta I\gamma(\%)$
PSI	Ψ
PWBA	PWBA
Q(	Q(
Q+	$Q(\varepsilon)$
Q-	$Q(\beta-)$
Q3D	Q3D
QA	$Q(\alpha)$
R	R
R(DCO)	R(DCO)
R**2	r^2
RO	r_0
RAMAN	Raman
RASMUSSEN	Rasmussen
RHO	ρ
RI	$I\gamma$
ROSE	Rose
S	s
S'	S'
S(	S(
S(2N)	S(2n)
S-FACTOR	S-factor
S-FACTORS	S-factors
S-VALUES	S-values
S/	S/
S=	S=
SA	$S(\alpha)$
SCHMIDT	Schmidt
SEEGER	Seeger
SELTZER	Seltzer
SEPTEMBER	September
SF	SF
SI(LI)	Si(Li)
SIGMA	σ
SIGNA	$\sigma(n\alpha)$
SIGNG	$\sigma(n\gamma)$
SILI	Si(Li)
SN	S(n)
SP	S(p)
STEFFEN	Steffen
SUB-COULOMB	sub-Coulomb
SUMOF	Σ
SY	syst
T	$T_{1/2}$
T)	t)
T,	t,
T/	T/
T1/2	$T_{1/2}$
T=	$T_{1/2}$=

ENSDF	TRANSLATION
TAU	τ
TELLER	Teller
TEMP	T
THETA	θ
TI	$I(\gamma+ce)$
TOF	TOF
TRISTAN	TRISTAN
TRIUMPH	TRIUMPH
U	U
UB	μb
UB*MEV	μb·MeV
UB/SR	μb/sr
UK	UK
US	μs
USA	USA
USSR	USSR
V	V
W	W
W.U.	W.u.
WEISSKOPF	Weisskopf
WIDTH	Γ
WIGNER	Wigner
WINTHER	Winther
X	x
X(	X(
X-RAY	X-ray
X-RAYS	X-rays
X=	x=
XG	$X\gamma$
XK	K X-ray
XKA	$K\alpha$ X-ray
XKA1	$K\alpha_1$ X-ray
XKA2	$K\alpha_2$ X-ray
XKB	$K\beta$ X-ray
XKB1	$K\beta_1$ X-ray
XKB1P	$K\beta_1'$ X-ray
XKB2	$K\beta_2$ X-ray
XKB2P	$K\beta_2'$ X-ray
XKB3	$K\beta_3$ X-ray
XKB4	$K\beta_4$ X-ray
XKG	(K X-ray)γ
XKO2	K(O2)X-ray
XKO3	K(O3)X-ray
XL	L X-ray
XLA	L_α X-ray
XLA1	$L\alpha_1$ X-ray
XLA2	$L\alpha_2$ X-ray
XLB	L_β X-ray
XLB1	$L\beta_1$ X-ray
XLB2	$L\beta_2$ X-ray
XLG	L_γ X-ray
XLG1	$L\gamma_1$ X-ray
XLG2	$L\gamma_2$ X-ray
XM	M X-ray
Y	y
Z	Z

ENSDF DICTIONARY

2-Feb-83

ENSDF	TRANSLATION
11/2(505)	11/2[505]
CONF=(N,NLJ)	configuration=(ν nlj)
CONF=((P,7/2(633))(P,3/2(521))(N,3/2(621))	configuration=((π 7/2[633])(π 3/2[521])(ν 3/2[621]))
CONF=(N,NLJ,-1)	configuration=$(\nu\ nlj)^{-1}$
CONF=(N,1G9/2)	configuration=$(\nu\ 1g_{9/2})$
CONF=(N,3G9/2,+3,23/2-)	configuration=$(\nu\ 3g_{9/2})^{+3}$23/2-
CONF=(N,3P1/2,-1)	configuration=$(\nu\ 3p_{1/2})^{-1}$
CONF=((208PB 3-)(P,1H9/2))15/2+	configuration=((^{208}Pb 3-)(π $1h_{9/2}$))15/2+
CONF=(P,1G9/2)	configuration=$(\pi\ 1g_{9/2})$
CONF=((P,1H9/2,+2,8+)(N,2F5/2,-3,11/2-))25/2-	configuration=((π $1h_{9/2}{}^{2}{}_{8+}$(ν $2f_{5/2})^{-3}{}_{11/2-}$)25/2-
CONF=(P,3G9/2,+3,23/2-)	configuration=$(\pi\ 3g_{9/2})^{+3}$23/2-

APPENDIX C

DATA EVALUATION CENTERS

a. National Nuclear Data Center
Brookhaven National Laboratory
Upton, NY 11973, U.S.A.

b. Nuclear Data Project
Oak Ridge National Laboratory
Oak Ridge, TN 37830, U.S.A.

c. Isotopes Project
Lawrence Berkeley Laboratory
Berkeley, CA 94720, U.S.A.

d. Idaho National Engineering Laboratory
E.G. and G. Idaho, Inc.
P.O. Box 1625
Idaho Falls, ID 83415, U.S.A.

e. Physics Department
University of Pennsylvania
Philadelphia, PA 19174, U.S.A.

f. Center for Nuclear Structure and Reaction Data of the U.S.S.R.
State Committee on the Utilization of Atomic Energy U.S.S.R.
46 Ulitsa Kurchatova
Moscow, D-182, U.S.S.R.

g. Data Centre
Leningrad Nuclear Physics Inst.
Gatchina, Leningrad Region
188350, U.S.S.R.

h. Fysisch Laboratorium
Princetonplein 5, P.P. Box 80 000
3508 TA Utrecht, The Netherlands

i. Oliver Lodge Laboratory
University of Liverpool
Liverpool L69 3BX, U.K.

j. Fachinformationszentrum Energie, Mathematik GmbH
Kernforschungszentrum
D-7514 Eggenstein-Leopoldshafen 2, F.R.G.

k. Centre d'Etudes Nucleaires
DRF-CPN
Cedex No. 85
F-38041 Grenoble Cedex, France

l. Division of Physics
Japan Atomic Energy Research Institute
Tokai-Mura, Naka-Gun
Ibaraki-Ken 319-11, Japan

m. Institute of Physics
University of Lund
Solvegatan 14
S-223 62 Lund, Sweden

n. Nuclear Data Project
Kuwait Institute for Scientific Research
P.O. Box 12009
Kuwait, Kuwait

o. Laboratorium voor Kernfysica
Proeftuinstraat 86
B-9000 Ghent, Belgium

p. Tandem Accelerator Laboratory
McMaster University
Hamilton, Ontario L8S 4K1
Canada

APPENDIX D

Conventions, Policies and Symbols in Nuclear Data Sheets

APPENDIX D-1

CONVENTIONS USED IN NUCLEAR DATA SHEETS

Units

Energies..........................	keV
Cross Sections.....................	barns
Magnetic dipole moments	nuclear magnetons
Electric quadrupole moments ...	barns

Uncertainties ("Errors") The uncertainty in any number is given one space after the number itself:

4.623 *3*	means 4.623 ±0.003
4.6 *12*	means 4.6 ±1.2
$5.4 \cdot 10^3$ *2*	means 5400 ±200
4.2 *+8−10*	means $4.2^{+0.8}_{-1.0}$
−4.2 *+8−10*	means −(4.2 *+10−8*)=$-4.2^{+0.8}_{-1.0}$

? Question Marks given after the energy value of a level or a radiation represent doubt as to the existance of that level or the radiation. A "?" given after the T1/2 value indicates that the assignment of that half-life to given level is not certain.

( ) Parentheses have the following interpretation for different quantities in the tabular data:

Quantity	Meaning of parentheses
J^π	J^π based upon weak arguments
L,Mult.	Probable but not definite
Other	Value deduced (not directly measured) or taken from other experiment(s).

Examples:

J^π=(1/2,3/2)$^-$

Weak arguments limit the spin to 1/2 or 3/2. Strong arguments indicate negative parity.

J^π=4$^{(+)}$

Strong arguments show the spin is 4; weak arguments suggest positive parity.

Mult.=M1(+E2)

Multipolarity is M1 with possible admixture of M2.

[ ] Brackets

7/2$^-$[514] Nilsson asymptotic quantum numbers, $K^\pi[N\ n_z\ \Lambda]$

Level Scheme Symbols

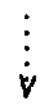
- - - - - - - Level of which the existence is not well-established

.... Adopted position of neutron- or proton-separation energy

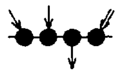
________ Well-established level

________ Ground-state or long-lived isomeric level

Radiation of which the position on the level scheme is not well-established



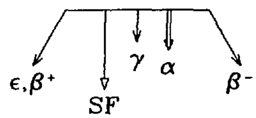
An expected strong transition that has not been observed



Beta, gamma, and alpha ray entering level are coincident with gamma ray leaving level

4380 0.4 7.5

4380-keV α-transition with intensity 0.4% and hindrance factor (HF) = 7.5



Decay modes of a level

404 4 8.5

β^--transition with endpoint energy, 404 keV measured directly; intensity, 4% of decays, usually found indirectly (from γ-intensities, a more accurate method if there are several β-groups); log *ft*=8.5

119 80 6.3

ε-transition with energy determined directly from endpoint of γ-continuum (to which is added K-shell electron binding energy) or from L-, K-capture ratio; with intensity 80%, usually determined indirectly (from γ-intensities); log *ft*=6.3

665 25

γ-transition with energy 665 keV and intensity 25 in the units specified in the drawing

% Number per 100 disintegrations of a nuclear level

APPENDIX D-2

Nuclear Data Sheets Symbols and Abbreviations

A	mass number*, A=Z+N
A_2, A_4	coefficients of Legendre polynomials in angular-correlation measurements
avg	average
B(EL), B(ML)	reduced EL, ML transition probability in $e^2 \cdot (barn)^L$, $\mu_N^2 \cdot (barn)^{L-1}$
calc, CA	calculated, calculation
CCBA	coupled-channel Born approximation
ce	conversion electron
chem	chemical separation
circ	circular
c.m.	center of mass
coef	coefficient
coin	coincidence
Coul. Ex.	Coulomb excitation
CP	circular polarization
cryst	crystal-diffraction spectrometer
C^2S, C^2S'	one-nucleon spectroscopic strength for pickup, stripping reactions
d	(1)descendent of, (2)deuteron, (3)day
D	dipole
DSA	Doppler shift attenuation
DWBA	distorted-wave Born approximation
DWIA	distorted-wave impulse approximation
E	energy
E(ε)	energy of electron-capture transition (endpoint of γ-continuum + K-electron separation energy of daughter)
E1, E2, EL	electric dipole, quadrupole, 2(L)-pole
E(res)	resonance energy
excit	excitation function
exp	experiment, experimental
F	fission
F-K	Fermi-Kurie (plot)
FWHM	energy resolution, full width at half maximum
g	gyromagnetic ratio*
GDR	giant dipole resonance
GQR	giant quadrupole resonance
g.s.	ground state
h	hour
H	magnetic field
HF	hindrance factor
hfs	hyperfine structure
HI	heavy ion
I	intensity
IAR	isobaric analog resonance
IAS	isobaric analog state
IBS	internal bremsstrahlung spectrum
IMPAC	*ion implantation perturbed angular* correlation technique
inel.scatt.	inelastic scattering
ion chem	chemical separation by ion exchange
IT	isomeric transition
J	total angular momentum quantum number*
K	projection of nuclear angular momentum J on nuclear symmetry axis
K, L, M	K-, L-, M-shell internal conversion
K/L	K-, L-conversion electron ratio
L	(1)orbital angular momentum quantum number*, (2)multipolarity
L(n), L(p)	L-transfer in neutron, proton transfer *reaction*
m	minute
M+	M+N+O+...
M1, M2, ML	magnetic dipole, quadrupole, 2(L)-pole
max	maximum
Moss	Mossbauer effect
ms	(1)mass spectrometer, (2)millisecond
mult.	multipolarity
N	neutron number*, N=A-Z
nm	nuclear magneton
NMR, NQR	nuclear magnetic, quadrupole resonance
norm.	normalization
P	(1)predecessor of, (2)proton, *(3)pico (as prefix)*
P(α)	α polarization
PAC	perturbed angular correlation
pc	proportional counter
p,$\gamma(\theta)$	angular distribution of γ-rays with respect to a proton beam
p,γ(t)	time distribution of photons with respect to a pulsed proton beam
P(n)	neutron polarization
pol	polarized, polarization
priv.comm.	private communication
PWBA	plane-wave Born approximation
Q	(1)reaction energy*, (2)disintegration energy*, (3)quadrupole moment*, in units of barns, (4)quadrupole
Q+	total disintegration energy in ε decay
Q-, Q(β-)	total disintegration energy in β- decay
Qα	total disintegration energy in α decay, E(α) + E(recoil)
R	$r_0A^{1/3}$, nuclear radius*
rel	relative
res	resonance
s	(1)magnetic spectrometer, (2)second
S	spectroscopic factor
S'	$[(2J_f+1)/(2J_i+1)]S$
S(n), S(p)	energy necessary to separate a neutron, proton from nucleus
scin	scintillation counter
semi	semiconductor detector
SF	spontaneous fission
spall	spallation
sr	steradian
syst ,SY	systematics
t	(1)time, (2)triton
T	(1)isotopic or isobaric spin, (2)temperature
Tz	Z-Component of isotopic or isobaric spin, (N-Z)/2
$T_{1/2}$	half-life*
th	thermal
thresh	threshold
tof	time-of-flight measurement
vib	vibrational
W.u.	Weisskopf single-particle transition speed
x	number of ejected neutrons, as in (α,xn)
y	year
Z	atomic number*, Z=A-N
α	(1)α particle, (2)total γ-ray internal conversion coefficient N(ce)/N(γ)*
α(K), α(L)	γ-ray internal conversion coefficient for electrons ejected from the K-, L-shell
$\alpha\gamma$, $\beta\gamma$, $\gamma\gamma$	coincidences of α's and γ's, β's and γ's, γ's and γ's
$\alpha\gamma(\theta,H,t)$, $\beta\gamma(\theta,H,t)$, $\gamma\gamma(\theta,H,t)$	$\alpha\gamma$-, $\beta\gamma$-, $\gamma\gamma$-coincidences as function of angle, magnetic field, time
β_2, β_3, β_L	quadrupole, octupole, 2^L-pole nuclear deformation parameter
$\beta\gamma$(pol), $\gamma\gamma$(pol)	polarization correlation of γ's in coincidence with β's,γ's
width=, $\Gamma(\gamma)$, Γ(n)	level width*, partial width for γ-, n-emission
$\gamma(\theta,H,T)$	γ-intensity as function of angle, magnetic field, temperature
$\gamma(\pm)$	annihilation radiation
δ	ratio of reduced matrix elements of (L+1)- to L-pole radiation with sign convention of Krane and Steffen, Phys.Rev. C2, 724 (1970)
ε	electron capture
εK, εL, εM	*electron capture from K-, L-, M-shell*
$\varepsilon(\gamma)$B(E2), ε(ce)B(E2)	partial B(E2) for photon, conversion electron detection
θ	indicates angular dependence
λ	(1)projection of particle angular *momentum* on nuclear symmetry axis, (2)radiation type, e.g., M1, M2...
μ	magnetic moment of particle*, given in nuclear magnetons
ν	neutron shell-model configuration
π	parity, proton shell-model configuration
σ	cross section*
σ(0)	cross section at resonance
$\Sigma(\gamma\gamma)$	*coincidence summing of γ-rays*
ω(K), ω(L)	K, average-L fluorescence yield
%α	percent α branching from level
%β	percent β- branching from level
%ε	percent (ε+β+) branching from level
%IT	percent (γ+ce) branching from level
%SF	percent spontaneous fission from level
$\langle r^2 \rangle$	root-mean-square of nuclear radius

Prefixes*

T	tera	$(=10^{12})$	m	milli	$(=10^{-3})$
G	giga	$(=10^{9})$	μ	micro	$(=10^{-6})$
M	mega	$(=10^{6})$	n	nano	$(=10^{-9})$
k	kilo	$(=10^{3})$	p	pico	$(=10^{-12})$
d	deci	$(=10^{-1})$	f	femto	$(=10^{-15})$
c	centi	$(=10^{-2})$	a	atto	$(=10^{-18})$

Symbols for Particles and Quanta*

n	neutron	π	pion
p	proton	μ	muon
d	deuteron	e	electron
t	triton	ν	neutrino
α	α-particle	γ	photon

* Recommended by Commission on Symbols, Units, and Nomenclature of International Union of Pure and Applied Physics

APPENDIX D-3

GENERAL POLICIES - "THEORY"

A reference "Theory 67Xy01" indicates theoretical predictions computed by the authors of 67Xy01. A reference "Theory" alone indicates a determination by the compiler of theoretical predictions described below.

Internal Conversion Coefficients

Theoretical conversion coefficients are obtained by spline interpolation (68Ha53) from tables of Hager and Seltzer (68Ha53) for the K-, $L_{1...3}$-, $M_{1...5}$-shells and of Dragoun, Plajner, and Schmutzler (71Dr11) for the (N+O+...)-shells. For the $N_{1...5}$-subshells, values are obtained by graphical interpolation from tables of Dragoun, Pauli, and Schmutzler (69Dr09). For K-, $L_{1...3}$-shells, conversion coefficients for transitions outside the E_γ, A-, or Z-ranges of Hager and Seltzer are obtained as follows: for $E_\gamma \leq 6000$ keV and for Z=3,6,10 and $14 \leq Z \leq 30$ interpolation from tables of Band *et al.* (76Ba63); for $E_\gamma > 2600$ keV, by graphical interpolation from tables of Trusov (72Tr09). For E0-transitions, K/L_1 and L_1/L_2 ratios are obtained by graphical interpolation from tables of Hager and Seltzer (69Ha61).

Angular Distribution and Correlation Coefficients

The coefficients $A_K(\delta)$ required for analysis of directional correlation, polarization correlation, directional distribution, and polarization distribution data are obtained as described by Steffen (71St47, 71St48). In particular, we adopt the phase convention for the mixing ratio, δ, defined by the authors (70Kr03). Particle parameters required for the analysis of correlation and distribution data involving conversion electrons are obtained by graphical interpolation from tables of Hager and Seltzer (68Ha54). The expression for the deorientation coefficient required to account for intermediate unobserved mixed radiations is given by Anicin (72An20).*

A tabulation of gamma-gamma directional coefficients is given by Taylor, et al. (71Ta32). These authors use the Steffen phase convention.

Penetration Parameters

Penetration parameters required for the analysis of internal conversion data and angular correlation or distribution data involving electrons are obtained by graphical interpolation from tables of Hager and Seltzer (69Ha61).

Internal Pair Conversion Coefficients

Theoretical internal pair conversion coefficients for A=E1, M1, E2 are obtained by graphical interpolation in Z, E from tables of Lombard, et al. (68Lo16).

* As pointed out by these authors, most earlier references which discuss this coefficient define it incorrectly

β-Decay Rate Probabilities

Log *ft* values, capture-to-positron ratios, and electron-capture ratios for allowed, first-forbidden unique, and second-forbidden unique transitions are obtained as described by Gove and Martin (71Go40). This reference also contains a tabulation of log *f* values and total capture-to-positron ratios for allowed and first-forbidden unique transitions.

Atomic Processes

X-ray fluorescence yields are obtained from Bambynek et al. (72Bb16) for Z≤92 and from Ahmad (79Ah01) for Z>92.

Electron binding energies for Z<84 are taken from Bearden and Burr (67Be73) and from Porter and Freedman (78Po08) for Z>84.

α-Decay Hindrance Factors

The α-hindrance factors (the ratio of the measured partial half-life for α-emission to the theoretical half-life) are obtained from the spin-independent equations of Preston (47Pr17). The nuclear radius for each even-even nucleus was determined by defining, for the g.s. to g.s. α-transition hindrance factor, HF≡1. For odd-A and odd-odd nuclei, the radius was chosen to be the average of the radii for the adjacent even-even nuclei (72El21). In the few cases where only one adjacent even-even radius was known, that value was corrected for the $A^{1/3}$ mass dependence and used in the calculation.

Electromagnetic Transition Rates

The Weisskopf single-particle estimates for the half-lives of electric and magnetic multipole radiation of energy E_γ are (52Bl97)

$$T_{1/2w}(EL)=0.190\left(\frac{L}{L+1}\right)\left(\frac{3+L}{3}\right)^2\frac{[(2L+1)!!]^2}{A^{2L/3}}\left(\frac{164.44}{E_\gamma(MeV)}\right)^{2L+1}\cdot 10^{-21}\ s$$

$$T_{1/2w}(ML)=3.255\ A^{2/3}\ T_{1/2w}(EL)$$

for nuclear radius $1.2\ A^{1/3}\cdot 10^{-13}$ cm.

Unweighted and Weighted Averages

If $x_1 \pm \Delta x_1$, $x_2 \pm \Delta x_2$, ...$x_n \pm \Delta x_n$ are n independent measurements of a given quantity, Δx_i being the uncertainty in x_i, then the weighted average of these measurements is $\bar{x} \pm \Delta\bar{x}$, where

$$\bar{x} = W\sum x_i/(\Delta x_i)^2,$$
$$W = 1/\sum(\Delta x_i)^{-2},$$

and $\Delta\bar{x}$ is the larger of

$$(W)^{1/2}$$
$$\text{and } [W\sum(\Delta x_i)^{-2}(\bar{x}-x_i)^2/(n-1)]^{1/2}.$$

The unweighted average of these same measurements is given by $\bar{x} \pm \Delta\bar{x}$, where

$$\bar{x} = \sum x_i/n,$$
$$\Delta\bar{x} = [\sum(\bar{x}-x_i)^2/n(n-1)]^{1/2}.$$

GENERAL POLICIES - "THEORY" continued

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SUMMARY OF BASES FOR SPIN AND PARITY ASSIGNMENTS

PROPOSITIONS ON WHICH STRONG ARGUMENTS ARE BASED

Ground States

1. The ground state of an even–even nucleus has $J^\pi = 0^+$.
2. Spin determinations by such techniques as atomic-beam resonance, paramagnetic resonance, electron–spin resonance, and optical spectroscopy give correct values.

Gamma Transitions

3. The agreement of the measured value of a single conversion coefficient with the theoretical value for a multipolarity which is well separated from the value for any other multipolarity determines the transition multipolarity.
4. In all other cases if there is no other evidence for multipolarity, agreement of two or more measured conversion coefficients or ratios with theoretical values is necessary in order to establish the multipolarities of a transition and its mixing ratio.
5. Since E_0 transition can proceed only by conversion or pair production, pure E_0 is ruled out if photons are observed.
6. Recommended upper limits for γ-ray strengths (Γ_γ/Γ_w, Γ_w–Weisskopf estimate) for various A-values are given below

	Γ_γ/Γ_w(Upper Limit)		
Character*	A=6–44[a,‡]	A=45–150[a,b]	A>150[c]
E1 (IV)	0.3[#]	0.01	0.01
E2 (IS)	100	300	1000
E3	100	100	100
E4	100	100[†]	
M1 (IV)	10	3	2
M2 (IV)	3	1	1
M3 (IV)	10	10	10
M4		30	10

* 'IV' and 'IS' stand for isovector and isoscalar
† Γ_γ/Γ_w(Upper Limit)=30 for A=90–150
\# Γ_γ/Γ_w(Upper Limit)=0.1 for A=21–44
‡ Γ_γ/Γ_w(Upper Limit)=0.003 for E1 (IS), 10 for E2 (IV), 0.03 for M1 (IS), 0.1 for M2 (IS)
a From 79En04
b From 81En06
c Deduced from **ENSDF** by M. J. Martin

Beta Transitions§

7a. If 3.6 < log *ft* < 5.9, the transition is allowed: ΔJ=0 or 1, Δπ=+ (no change in parity). For the mass region around Z=82, the upper limit should be lowered to 5.1.
7b. If 3.6 < log *ft* < 6.4, the transition is not $0^+\to0^+$. Superallowed (ΔT=0) $0^+\to0^+$ transitions have log *ft* in the range 3.48 to 3.50. Isospin forbidden (ΔT=1) $0^+\to0^+$ transitions have log *ft* > 6.4.
8. If log $f^{1u}t$ < 8.5,* ΔJ=0,1; Δπ=±.
9. If log *ft* < 11.0, ΔJ=0,1; Δπ=± or ΔJ=2, Δπ=−.
10. If log *ft* < 12.8, ΔJ=0,1,2; Δπ=±.
11. If log $f^{1u}t$ ≥ 8.5† and if the Fermi plot has the curvature corresponding to a shape factor (p^2+q^2), then the transition is first-forbidden unique (ΔJ=2, Δπ=−).

See "β-Decay Rate Probabilities" on page App-D-iv. Note that log $f^{1u}t$=log $f't$+1.079).

* (log $f't$ < 7.4)
† (log $f't$ ≥ 7.4)

γγ Directional Correlation

$$W(\theta) = \sum_{k\text{-even}} A_k P_k\,(\cos\theta).$$

12. If a gamma-gamma directional-correlation experiment yields $A_2\approx+0.36$ and $A_4\approx+1.1$, then the spin sequence is $0\to2\to0$.
13. Results of γγ(θ) are strong evidence for excluding spin sequences for which the theoretical A_2 or A_4 falls well outside the experimental range.

βγ Directional Correlation

$$W(\theta) = \sum_{k\text{-even}} A_k(\beta)A_k(\gamma)P_k(\cos\theta).$$

14. If $|A_2(\beta)| \geq 0.1 (A_4=0)$, the transition is not allowed. The converse is not true.
15. If $A_4(\beta) \neq 0$, the transition is neither allowed nor first-forbidden.
16. If $A_4(\beta)=0$, the transition is allowed or first-forbidden.

βγ Polarization Correlation

$$P(\theta) = \frac{\sum_{k\text{-odd}} A_k(\beta)A_k(\gamma)P_k(\cos\theta)}{W(\theta)}$$

17. In allowed transitions,

β^-	$A_1(\beta)<0$ if $J_i=J_f$
β^+	$A_1(\beta)>0$ if $J_i=J_f$
β^-	$A_1(\beta)\geq0$ if $J_i=J_f+1$
	$A_1(\beta)<0$ if $J_i=J_f-1$
β^+	$A_1(\beta)\leq0$ if $J_i=J_f+1$
	$A_1(\beta)>0$ if $J_i=J_f-1$

18. If $A_3(\beta)\neq0$, the β-transition is not allowed. The converse is not always true.

Reactions

19. Low-energy Coulomb excitation is predominantly E2 excitation.
20. Coulomb excitation determines J^π if the excitation probability agrees with the calculated values of Alder et al., Kgl. Danske Videnskab. Selskab, Mat.-Fys. Medd. 32, No. 8 (1960).
21. The spin of the compound nuclear state resulting from thermal-neutron capture is equal to the spin of the target nucleus plus or minus ħ.
22. Primary γ's from neutron capture are E1, M1, E2, or M1+E2.
23. If the angular distribution in a single-nucleon transfer reaction can be fitted with a unique ℓ-value, the spin of the final state J_f is related to the spin of the inital state J_i by

$$\vec{J}_f = \vec{J}_i + \vec{\ell} + \vec{s}$$

with parity change if ℓ is odd.
24. For Z<~50 and Z≈82, if the vector analyzing power for a single-nucleon transfer reaction shows a clear preference between J=ℓ+1/2 and J=ℓ−1/2 and if the ℓ-value is known, then the J-value is determined.

The limitation in the regions of applicability results from a lack of measurements in other regions rather than an expected or observed violation.

§ See 73Ra10

SUMMARY OF BASES FOR SPIN AND PARITY ASSIGMENTS - continued

PROPOSITIONS ON WHICH STRONG ARGUMENTS ARE BASED continued

25. If the angular distribution can be fitted with a unique L-value the J^π of the final state is related to the J^π of the initial state by $\vec{J}_f = \vec{J}_i + \vec{L}$, $\pi_f\pi_i=(-1)^L$, for the following cases
    a. A strong group observed in (p,t), (t,p), and (^{3}He,n) reactions (strong groups are assumed to result from two identical nucleons transferred in a relative s-state)
    b. A strong group observed in the α-particle reaction (^{6}Li,d).
    c. (e,e') and (α,α') inelastic scattering.
26. In reactions with $J^\pi=0^+$ target, projectile, and ejectile, if the yield of a group at 0° or 180° is
    a. non-zero, the parity of the final state is $(-1)^{Jf}$
    b. zero at several uncorrelated energies, the parity of the final state is $(-1)^{Jf+1}$

In reactions with a polarized $J^\pi=1$ projectile in the m=0 substate, with $J^\pi=0^+$ ejectile and target, if the yield of a group at 0° or 180° is
    a. non-zero, the parity of the final state is $(-1)^{Jf+1}$
    b. zero at several uncorrelated energies, the parity of the final state is $(-1)^{Jf}$

Magnetic Moments

27. In nonrotational regions, if the known spin and magnetic moment of a level lead to an expected shell-model state by use of the Schmidt diagram, the level parity is determined.
28. In rotational regions, if the known spin and magnetic moment of a level agree with theoretical values for only one expected Nilsson level, the level parity is determined.

Deformed Region - Band Structure

Symbol	Evidence
D	Data from β- or γ-transitions suggest $J^\pi = 2^+$
x	The level is Coulomb excited
y	The level energy is given by the rotational level-energy formula
z,z'	The inertial parameter, decoupling parameters, fits the local trend

In terms of the above types of evidence, the following rules can be stated for nuclei in the rotational regions, $90 \le N \le 112$, and $Z > 87$.

29. For the first excited state in an even-even nucleus, x or Dz is sufficient to assign a spin and parity of 2^+.
30. A level may be assigned to the ground-state rotational band on evidence of type xz or yz, provided the ground-state spin is well known.
31. A level may be assigned to a rotational band on evidence of type yz, provided at least one member of the band has well-known spin.
32. For K=1/2 bands, yz' is sufficient evidence to assign spins to the levels.

Alpha Decay

33. In odd-A nuclei, levels connected by α-transitions have the same spin and parity if the hindrance factor is less than 4.
34. For α-decay between two states, one of which has J=0, the parity change is given by $\Delta\pi=(-1)^{\Delta J}$.

PROPOSITIONS ON WHICH WEAK ARGUMENTS ARE BASED

1. In cases where gammas of one multipolarity "cluster" in one time region in the half-life vs. energy plot, as is true for M4's, other γ's whose half-lives fall in this cluster may be assigned the corresponding multipolarity.
2. In cases where a cluster of two multipolarities occupy one time region e.g. M1 and E2, a new gamma of which the half-life falls in this region may be assigned one of the two multipolarities or a mixture o. the two.
3. Whenever $\Delta J \ge 2$, an appreciable part of the gamma transition proceeds by the lowest possible multipole order.

This statement is based on the scarcity of counter-examples and the observation that few E2 γ's are as slow as M3's, few M2's as slow as E3's, etc.

4. Low-lying states of odd-A nuclei have shell-model spins and parities except in the regions where deformations appear. This argument is much stronger when supported by expected cross-section strengths (C^2S) in single-nucleon transfer reactions.

It is recognized that some shell-model predictions are stronger than others. For example, the shell model would mildly deny that the ground-state J^π of the 39th proton be $3/2^-$, but emphatically deny its being $3/2^+$. However, we have not included this distinction here and consider that all shell-model arguments are weak.

5. The spin and parity of a parent state may be inferred from the measured properties of its assumed isobaric analog resonance, and vice versa.
6. In regions of nuclear deformation, the Nilsson model can be used to limit the possible spins and parities.
7. Statements similar to 4 and 6 based on other models.
8. Statements based on interpolation or extrapolation of regional trends.
9. All statements connected with the nonobservation of expected transitions.

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