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ENSDF Analysis and Utility Codes

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ENSDF Analysis and Utility Codes

- Platforms
- Overview of the Programs
- Programs Used for Various Types of ENSDF Datasets
  - All Types of Datasets
  - Adopted
  - Decay
  - Reaction
- Additional Notes on Some of the Codes

ENSDF Analysis and Utility Codes
Platforms

- Most of the programs are available for the following:
  - ANSI standard Fortran 77 or Fortran 95
  - LINUX and UNIX (gnu f77 FORTRAN, INTEL FORTRAN 90, or Lahey/Fujitsu FORTRAN 95)
  - Windows 95/98/ME/NT/2000/XP/VISTA (COMPAQ/DEC Visual Fortran)
- For LINUX, UNIX, and Windows, executables are also provided.

ENSDF Analysis and Utility Codes

Overview

- ADDGAM — Adds gammas to an adopted dataset
- ALPHAD — Calculates α R_0's, Hindrance Factors and theoretical $T_{½}(\alpha)$'s
- *BrIcc/HSICC* (Band-Raman Internal Coefficients/ Hager-Seltzer Internal Conversion) — Interpolates internal conversion coefficients – BrIcc adopted.
- BrIccMixing — Calculates mixing ratios from internal conversion coefficients
- COMTRANS (Comments Translation) — Translates comment records in ENSDF dataset to a “rich text” format
- DELTA — Analyzes angular correlation data
- ENSDAT (Evaluated Nuclear Structure Drawings and Tables) — Produces high quality drawings and tables in the Nuclear Data Sheets style

ENSDF Analysis and Utility Codes

Overview - 3

- RadList (Radiation Listing) — Calculates atomic & nuclear radiations. Checks energy balance
- RULER — Calculates reduced transition probabilities
- TREND (Tabular Representation of ENSDF) — Tabular display of ENSDF data

ENSDF Analysis and Utility Codes
All Types of Datasets

- Applicable programs are FMTCHK, ENSDAT, PANDORA, and TREND.
- FMTCHK should be run after any manual changes to the file.
- ENSDAT may be used to visually check the data.
- If you are considering combining several datasets (*e.g.*, from XUNDL), PANDORA may be useful.
- TREND may be used to visually check the data.

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Adopted Levels, Gamma Datasets — 1

- Applicable programs are ADDGAM, GTOL, BrIcc, PANDORA, and RULER.
- ADDGAM and PANDORA are useful in constructing the dataset.
- PANDORA used iteratively to aid in physics decisions, checking assignments, and updating source datasets based on changes in the adopted data.
- GTOL useful only in obtaining the least-squares adjustment of the level energies.
  - Matrix may occasionally be singular.

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Adopted Levels, Gamma Datasets — 2

- RULER may be used in either of two modes:
  - Comparison mode to provide additional information in obtaining γ-multipolarity assignments.
  - Should also be run to provide the BEλW's and BMλW's.
  - BrIcc/HSICC should be run before RULER.
- BrIcc should be run to provide the internal conversion coefficients.
  - Note that there is no need to delete the "S G" records generated by code.

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Decay Datasets — 1

- Applicable programs are ALPHAD (for α decay), GABS, GTOL, BrIcc, LOGFT (for $\beta^{\pm}/\varepsilon$ decay), RadList, and RULER.
- ALPHAD should be used to obtain the hindrance factors and, for even-even ground-state nuclei, R_0. For other nuclei, an R_0 must be supplied.
- GABS may be used to combine the data from up to three sources to obtain I_γ-normalization (NR), the branching ratios (BR), and absolute I_γ's.
  - BrIcc should run on the input data or the α's from the adopted dataset should be used.

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Decay Datasets — 2

- GTOL may be used to:
  - Provide a least-squares adjustment of the level energies.
  - Check the uncertainties and placement of the γ's.
  - Obtain the intensities of particles feeding the levels.
    - Should be done before ALPHAD and LOGFT are employed.
  - May be useful in deriving I_γ-normalization (NR).
- BrIcc may be used to:
  - Check experimentally measured α's against theory.
  - If the adopted α's are not used, to produce this information for the data set.

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Decay Datasets — 3

- LOGFT is required to obtain the log *ft*'s, $I_{\beta+}$ and I_{ε}, and partial electron-capture fractions.
  - Should be done before using RadList.
  - If one is not using measured intensities, GTOL should be used to obtain $I_{\beta-}$ and $I_{\varepsilon+\beta+}$.
- RadList should be used to:
  - Check the calculated energy deposited with that based the Q-value and branching ratio.
  - To compare to experimentally obtained X-ray intensities
  - Check results against integral measurements (*e.g.*, $<E_{\beta\pm}>$)
  - Unresolved discrepancies should be noted in the dataset.
  - BrIcc and LOGFT should have been used before doing these checks.

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Decay Datasets — 4

- RULER may be used to check or further limit multipolarities based on other methods (*e.g.*, from experimental conversion coefficients).

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Reaction Datasets — 1

- Applicable programs are GTOL, BrIcc, and RULER.
  - For (thermal n,γ) datasets, RadList may also prove of use.
- GTOL's primary use is to do a least-squares adjustment of the level energies and to check the uncertainties and placement of the γ's.
  - If ΔE_γ's are not given and a good estimate of these cannot be obtained, it may be better to use the authors' level energy values.
  - Also useful for checking for intensity imbalance problems if relative intensities are given.

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Reaction Datasets — 2

- BrIcc may be used to check experimentally measured α's against theory.
  - Very useful to include α's and partial α's for (thermal n,γ) datasets.
- RadList may be used to check the energy balance of (thermal n,γ) datasets by tricking it.
  - Change the DSID on the ID record to indicate IT decay
  - Add an appropriate Parent record ($E_{level}=S_n$)
  - Add a BR of 1.0 on the Normalization record.

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Additional Notes - 1

- COMTRANS
  - Should <u>not</u> be run on ENSDF or XUNDL files submitted to the NNDC.
    - ^A4 → A4 → A{-4} → a{-4}
    - T→T{-1/2}→T{-1/2}T{-1/2}→T{-1/2} T{-1/2}T{-1/2}T{-1/2}→ ...
  - Useful to run before using Isotope Explorer 2 or ENSDAT.
- ENSDAT
  - Keynumber list generated by ENSDAT may be used to check the keynumbers
  - Layout commands may be embedded in the input.
    - See ENSCOMDS.TXT
    - Need to be removed before submission to the NNDC
  - “View” option available if you have a PostScript viewer such as GhostView installed.

ENSDF Analysis and Utility Codes
Additional Notes - 2

- NSDFLIB — Subroutine package used in all programs, except DELTA, GABS, and LWEIGHT
  - ANSI standard FORTRAN77
  - ANSI standard FORTRAN95 with a couple of exceptions
- RadList
  - Calculated uncertainties may be overestimated.
    - Total energy deposited by γ's calculated as $\Sigma BR \times NR \times E_\gamma \times I_\gamma$ instead of $BR \times NR \Sigma E_\gamma I_\gamma$.
  - Uses the first partial conversion coefficient found.
    - If EKC is encountered before KC, EKC will be used in the calculations.

ENSDF Analysis Detailed

Alphad

- Hinderance Factor — HF
  - Experimental $T_{1/2}(\alpha)$/Theoretical $T_{1/2}(\alpha)$
  - Theoretical value from 1947Pr17 (M.A. Preston)
  - Assumption is that 0^+ to 0^+ from even-even nuclei are fastest (HF = 1)
- Radius parameter (r_0) calculations
  - Alphad calculates r_0 for decays from even-even nuclei
    - See 1998Ak04 (Y.A. Akovali) for even-even values
  - Evaluator must interpolate to obtain odd-even and odd-odd cases and add to ENSDF file for alphad to calculate HF

alphad

Obtaining the radius parameter

- Odd N

  $$r_0(Z,N) = [r_0(Z,N-1) + r_0(Z,N+1)]/2$$

- Odd Z

  $$r_0(Z,N) = [r_0(Z-1,N) + r_0(Z+1,N)]/2$$

- Odd-Odd

  $$r_0(Z,N) = [r_0(Z-1,N+1) + r_0(Z-1,N-1) + r_0(Z+1,N+1) + r_0(Z+1,N-1)]/4$$

alphad

More on hinderance factors

- Odd-odd and even-odd nuclei have relatively longer half-lives than theoretical calcs (l=0 decay) due to hinderance factors
- GS transition from odd nucleus can only take place if the unpaired nucleon becomes part of the α particle, and so a pair is broken

alphad

Hinderance factors

- 1-4
  - "favored". Alpha assembled from low lying pairs of nucleons in parent nucleus
- 4-10
  - Mixing or favorable overlap between initial and final nuclear states
- 10-100
  - Spin projs parallel but Ψ overlap not favorable
- 100-1000
  - Change in parity, parallel spin projs
- > 1000 (change in parity, not parallel spin projs)

alphad

Example ENSDF

cm249.alpha

```
249CM    253CF A DECAY                 1968BE21                  11NDS    201108
249CM  H TYP=FUL$AUT=KHALIFEH ABUSALEEM$CIT=NDS 112, 2129 (2011)$
249CM2 H CUT=31-Dec-2010$
249CM  N 1                      0.0031 4
253CF  P 0.0          7/2+             17.81 D   8              6126      4
253CF cP $Q from 2011AuZZ, 2009AuZZ and 2003Au03
249CM c  J({+253}Cf g.s.)=7/2+, therefore, the favored |a branch
249CM2c  (HF=1.3 {I2}) is unlikely to go to the {+249}Cm g.s with J=1/2(+).
249CM3c  It most probably feeds the 48-keV (7/2+) state.
249CM cA E         Recommended value from 1991Ry01, based on adjusted values
249CM2cA from 1968Be21, 1966Rg01; 2009AuZZ
249CM cA IA        Recommended value from 1991Ry01, based on measurements of
249CM2cA 1968Be21 and 1966Rg01
249CM cA HF        r{-0}({+249}Cm)=1.509 {I5}
249CM  L 0.0          1/2(+)
249CM  L 48.758      (7/2+)              23 US
249CM cL T         from delayed coin (1966As12)
249CM  A  5980     4  94.7   9  1.3    2
249CM  L   110     1  (9/2+)
249CM  A  5920     5  5.3    19 11     5
```

Beta and EC decay: logft

- Needs logft.dat for radial wave function data
  - On Windows or Linux, is contained in the compressed file
  - Also under "Input data" on the main logft website.

Example of before logft

tl205noft.beta

```
205TL    205HG B- DECAY                1971HI01                  04NDS    200404
205TL  H TYP=FUL$AUT=F.G. KONDEV$CIT=NDS 101, 521 (2004)$CUT=1-Feb-2004$
205TL cG E,RI$From 1971Hi01, unless otherwise specified.
205TL cG M,MR$From adopted gammas, unless otherwise specified.
205TL cL E$From a least-squares fit to E|g.
205TL cL J$From adopted levels.
205HG  P 0.0          1/2-            5.14 M   9              1533     4
205TL  N 0.022     10           1       1.0
205TL cN NR$based on I|b{+-}=3.2% {I15} to the 203.7 level.
205TL2cN The total energy realized in |b{+-} decay of {+205}Hg is calculated
205TL3cN using RADLST as
205TL4cN 1534 keV {I23}. This value is in a very good agreement with
205TL5cN Q(g.s.)=1533 keV {I4}, thus suggesting that the decay scheme
205TL6cN is complete.
205TL  L 0.0          1/2+
205TL  B              96.8   15
205TL  L     203.6519 3/2+            1.46 NS   8
```

After logft (logft.new)

logft.new

```
205TL     205HG B- DECAY                 :01                  04NDS    200404
205TL  H TYP=FUL$AUT=F.G. KONDEV$CIT      521 (2004)$CUT=1-Feb-2004$
205TL cG E,RI$From 1971Hi01, unless       specified.
205TL cG M,MR$From adopted gammas, u      rwise specified.
205TL cL E$From a least-squares fit tc
205TL cL J$From adopted levels.
205HG  P 0.0          1/2-            5.14 M    9              1533     4
205TL  N 0.022     10          1        1.0
205TL cN NR$based on I|b{+-}=3.2% {I15} to the 203.7 level
205TL2cN The total energy realized in |b{+-} decay of {+20
205TL3cN using RADLST as
205TL4cN 1534 keV {I23}. This value is in a very good agre
205TL5cN Q(g.s.)=1533 keV {I4}, thus suggesting that the d
205TL6cN is complete.
205TL  L 0.0          1/2+
205TL  B              96.8   15            5.257 11
205TLS B EAV=540.4 17
205TL  L     203.6519 3/2+            1.46 NS   8
```