Standard neutron capture γ-ray data methodology

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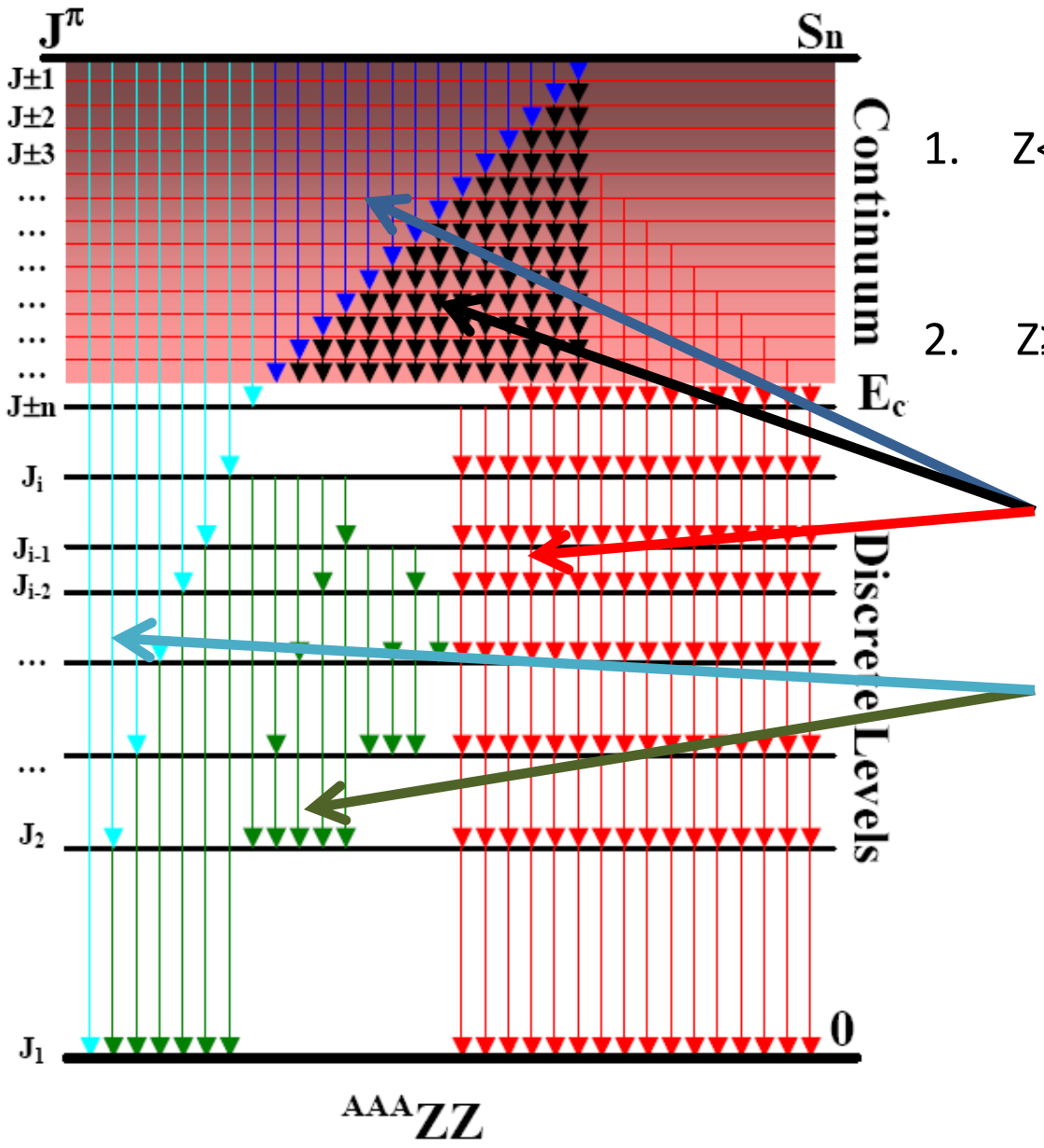
Introduction

The horizontal evaluation of (n,γ) data for the IAEA/LBNL EGAF database is the primary activity in the LBNL Isotopes Project evaluation plan.

- New measurements for all elements with guided neutron beams are not in ENSDF.
- Analysis of total radiative neutron cross sections indicated widespread discrepancies.
- Statistical model calculations will improve the Adopted Levels, Gammas data in ENSDF and RIPL.
- A new community of data evaluators is being generated around this topic.

A standalone (n,γ) database evaluated by experts should be separated from ENSDF and published independently.

Summary of (n,γ) analysis



1. Z<20 decay scheme complete

$$\sigma_0=\Sigma\sigma_\gamma(GS)=\Sigma\sigma_\gamma(CS)$$

2. Z≥20 must corrected for continuum

Continuum – calculated with statistical model code DICEBOX

Below E_{crit} – measured primary, secondary γ-rays from EGAF. Level scheme from ENSDF, modified to RIPL standard and consistency with DICEBOX

$$\sigma_0=\Sigma\sigma_\gamma(GS)_{expt}+\Sigma\sigma_\gamma(GS)_{calc}$$

Data Sources

EGAF – only reliable source of cold/thermal capture γ-ray cross section data.

- Standardization data
- Efficiency calibration <1% 0.5-6 MeV, <3% elsewhere
- Compton suppressed data
- Measurements for all natural elements, isotopic measurements available upon request

ENSDF – additional relative γ-ray measurements from other sources, e.g. Grenoble crystal data. Also decay data.

XUNDL/Literature – updates beyond ENSDF

Atlas on Neutron Resonances – recommended σ_0 data, references.

CSISRS – references to cross sections with data included

DDEP – decay data library

Level Scheme

- Starting with ENSDF Adopted Levels, Gammas place capture γ-ray into the level scheme.
- Check literature for relevant new level data and update the level scheme as necessary
- Add unobserved γ-rays from Adopted Gammas using adopted branching ratios.
- Add conversion coefficients using BRICC.
- Check the intensity balance through the level scheme.
    1. If statistically self consistent go on to next step.
    2. If not, re-evaluate level scheme for possible errors and revise if possible.

DICEBOX Calculations

- If level scheme is fairly complete, typically for Z<20, no calculations are needed. Go to next step.
- Choose DICEBOX parameters for level density and photon strength based on local systematics.
- Run DICEBOX.
- Compare calculated capture state width with calculation and check the population/depopulation plot.
- Vary input parameters and repeat calculation until good agreement is reached.
- Check for outliers in the population/depopulation plot. These are likely to be due to problems with the data. Try different spins/parities to improve the comparison. Go back to previous step to resolve the problem.

This tends to be the most difficult part of the analysis

Analysis of Activation Decay Data

During prompt (n,γ) measurement delayed γ-rays from activation products are also seen. They must be corrected for saturation during bombardment where the total number of γ-ray decays at infinite time N_0 is given by

$$N_0 = N(1 - e^{-\lambda t})/e^{-\lambda t}$$

Where N is the observed number of γ-ray decays observed during bombardment, $\lambda = ln(2)/t_{1/2}$, and t is the bombardment time.

Cross Section Calculation

Prompt Gammas

$$\sigma_0 = \Sigma\sigma_\gamma(GS)^{expt,E<Ecrit} + \Sigma\sigma_\gamma(GS)^{calc,E>Ecrit}$$

Activation Gammas

$$\sigma_0 = \sigma_\gamma / P_\gamma$$

Either σ_0 or P_γ can be determined this way so both values should be reconciled into a consistent result.

Publication

1. Final results should be published in a peer reviewed journal.
2. Detailed results will be published in EGAF database
   a) Compilation of literature σ_0 values and recommended value.
   b) Adopted Levels, Gamma in RIPL format
   c) Adopted (n,γ) dataset with σ_γ, intensity balances, S_n, and photon strengths for primary transitions
   d) Supporting (n,γ) datasets from literature
   e) Adopted decay dataset $\rightarrow$ DDEP
3. Future – EGAF will extend coverage to higher energy data