Absolute and Relative γ-Ray Intensities in ENSDF

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The Need for Both Types of Intensities

Relative Intensities
Usually are known more precisely.

Absolute Intensities
Usually are known less precisely.

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USNDP Annual Meeting
November 7-9, 2006

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The Use of Absolute Intensities

Absolute γ-ray intensities are used in:

Nuclear structure, mainly for normalizing emitted radiations to a scale per nuclear transformation.

Applied research, mainly for estimating amounts of radionuclides of known specific activities. For example: ^{238}U in uranium ore.

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How to Obtain them

We determine absolute γ-ray intensities:

Experimentally
Using the decay scheme

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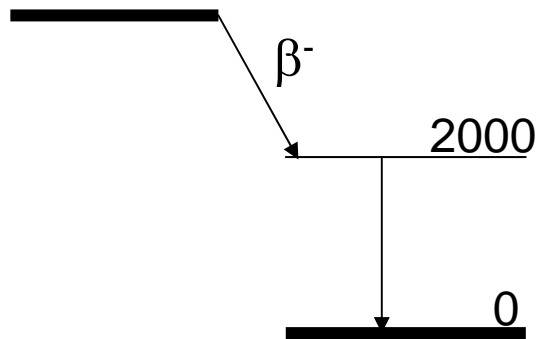
Uncertainties in Absolute γ-Ray Intensities

Measurement of an absolute intensity and *its uncertainty* for a single γ ray. Propagating linearly this uncertainty to other γ rays.
This is a trivial procedure.

Deducing absolute intensities and *their uncertainties* from relative intensities using the decay scheme.
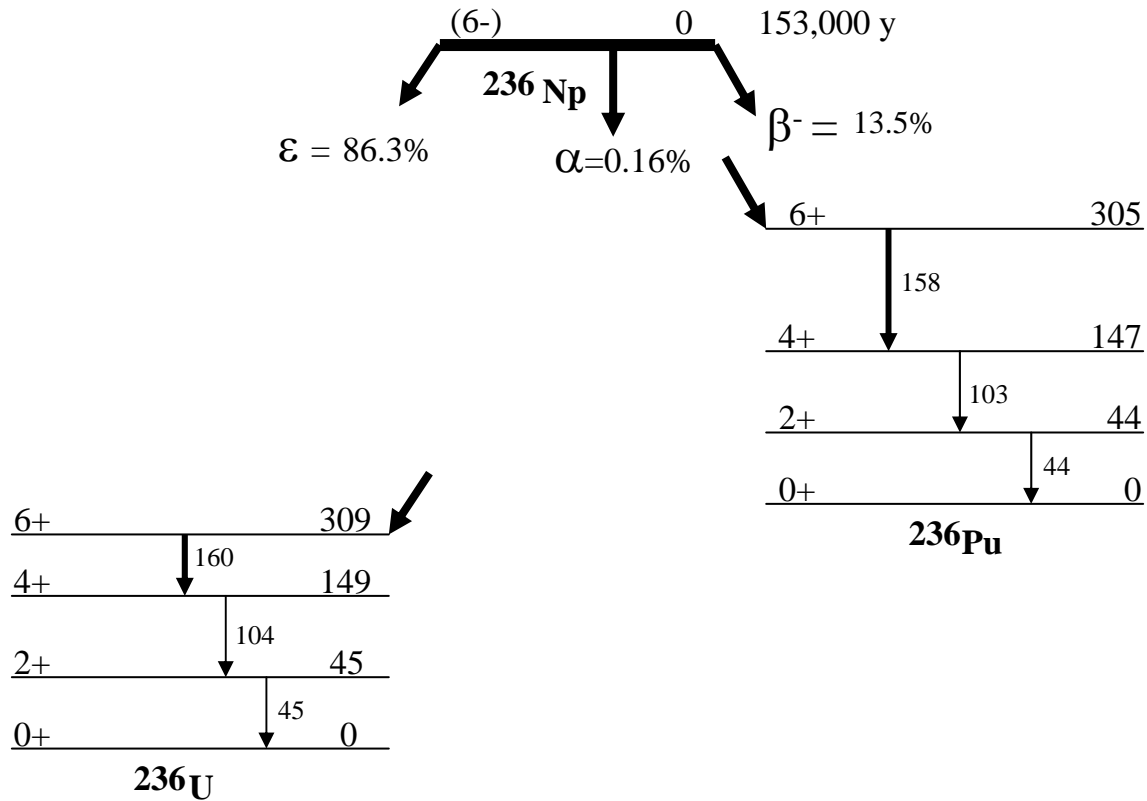**This is not a trivial procedure**.

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A Simple Decay Scheme

I_γ = 235 (5) photons/sec

Internal conversion coefficient α = 0

β⁻

2000

0

Normalization factor N = 100 / 235 (5)

Absolute intensity I_γ(%) = (235 (5)) 100 / (235 (5)) = 100

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A Real Example

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Decay-Scheme Normalization

$$[I\gamma_{160}(1 + \alpha_{160}) + I\gamma_{158}(1 + \alpha_{158})]\ N=100 - \%\alpha = 99.84\ 6$$
$$N=0.313\ 12$$

Incorrect calculation

$$I\gamma_{160}(\%) = I\gamma_{160} \times N = 100\ 4 \times 0.313\ 12 = 31.3\ 18$$
5.8% fractional uncertainty

Correct calculation

$$I\gamma_{160}(\%) = 99.84\ 6\ /\ [(1+\alpha_{160}) + I\gamma_{158}(1 + \alpha_{158})/\ I\gamma_{160}] = 31.3\ 4$$
1.3% fractional uncertainty

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CONCLUSION

The knowledge of relative γ-ray intensities and a normalization factor N may not be sufficient for deducing uncertainties in absolute γ-ray intensities.

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Report File

- Current date: 10/11/2006
- 236NP EC DECAY (154E+3 Y)
- NR=   0.363   BR=   0.863   8
- FOR INTENSITY UNCERTAINTIES OF GAMMA RAYS NOT USED IN CALCULATING NR,
- COMBINE THE UNCERTAINTY IN THE RELATIVE INTENSITY IN QUADRATURE
- WITH THE UNCERTAINTY IN THE NORMALIZING FACTOR (NR x BR).
- FOR THE FOLLOWING GAMMA RAYS:
- E= 45.23   3 %IG=0.13 4 PER 100 DECAYS.
- E= 104.23   2 %IG=7.2 4 PER 100 DECAYS.
- E= 160.33   2 %IG=31.3 4 PER 100 DECAYS.(Compare with 31.3 18)
-
- 236NP B- DECAY (154E+3 Y)
- NR=   2.32   BR=   0.135   8
- FOR INTENSITY UNCERTAINTIES OF GAMMA RAYS NOT USED IN CALCULATING NR,
- COMBINE THE UNCERTAINTY IN THE RELATIVE INTENSITY IN QUADRATURE
- WITH THE UNCERTAINTY IN THE NORMALIZING FACTOR (NR x BR).
- FOR THE FOLLOWING GAMMA RAYS:
- E= 44.6   1 %IG=0.0182 15 PER 100 DECAYS.
- E= 102.82   2 %IG=0.91 7 PER 100 DECAYS.
- E= 158.35   2 %IG=4.23 25 PER 100 DECAYS.(Compare with 4.2 4)

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Output File from Modified GABSPC Computer Code

- 236NP P 0   (6-)   154E+3 Y 6   930   50
- 236U   236NP EC DECAY (154E+3 Y)
- 236U   N   0.363   0.863 8
- 236U   L 0   0+
- 236U   L 45.242   2+
- 236U   G 45.23   3 0.4   1 E2   589
- 236U 2 G %IG=0.13 4
- 236U CG %IG   From recommended decay-scheme normalization.
- 236U   L 149.477   4+
- 236U   G 104.23   2 23   1 E2   10.99
- 236U 2 G %IG=7.2 4
- 236U CG %IG   From recommended decay-scheme normalization.
- 236U   L 309.784   6+
- 236U   G 160.33   2 100   4 E2   1.76
- 236U 2 G %IG=31.3 4
- 236U CG %IG   From recommended decay-scheme normalization.
-
- 236PU   236NP B- DECAY (154E+3 Y)
- 236NP P 0   (6-)   154E+3 Y 6   480   50
- 236PU N   2.32   0.135 8
- 236PU L 0   0+
- 236PU L 44.6   2+
- 236PU G 44.6   1 0.058   4 E2   743
- 236PU2 G %IG=0.0182 15
- 236PU CG %IG   From recommended decay-scheme normalization.
- 236PU L 147.4   4+
- 236PU G 102.82   2 2.9   2 [E2]   13.87
- 236PU2 G %IG=0.91 7
- 236PU CG %IG   From recommended decay-scheme normalization.
- 236PU L 305.8   6+
- 236PU G 158.35   2 13.5   7 [E2]   2.19
- 236PU2 G %IG=4.23 25
- 236PU CG %IG   From recommended decay-scheme normalization.

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