$^{90}Y^{m}$ - Comments on evaluation of decay data by V. Chisté

This evaluation was completed in 2005. The literature available by August 2005 was included.

1 Decay Scheme

$^{90}Y^{m}$ disintegrates 99.9981 (2) % through isomeric transition to the ^{90}Y ground state and 0.0019 (2) % by β^- emission to the 2318 keV excited state in ^{90}Zr. The decay scheme, level energies, spins and parities and half-lives of excited states are based on the evaluation of E. Browne (1997Br34).

2 Nuclear Data

The Q value in the decay of $^{90}Y^{m} \rightarrow {}^{90}Zr$ (2961.8 (17) keV) has been calculated from the following relation:

$$Q(^{90}Y^{m} \rightarrow {}^{90}Zr) = Q(^{90}Y \rightarrow {}^{90}Zr) + Q(^{90}Y^{m} \rightarrow {}^{90}Y)$$

Both latter values are from the atomic mass evaluation of Audi *et al.* (2003Au03).

The experimental $^{90}Y^{m}$ half-life values (in hours) are given in Table 1:

Table 1: Experimental values of $^{90}Y^{m}$ half-life

Reference	Value (h)
Carter-Waschek and Linder (1961Ca12)	3.2 (1)
Heath et al.(1961He09)	3.14 (10)
Haskin and Vandenbosch (1961Ha17)	3.19 (6)
Abecasis et al.(1962Ab03)	3.15 (5)
Grench et al.(1967Gr02)	3.19 (1)
Anthony et al.(1992An19)	3.244 (5)
Adopted	**3.19 (6)**

The weighted average has been calculated with the LWEIGHT computer program (version 3).

The evaluator has chosen to take into account the seven values with associated uncertainties for the statistical processing. The largest contribution to the weighted average comes from the value of Anthony (1992An19) amounting to 79 %. The LWEIGHT program has increased the uncertainty for the 1992An19 value from 0.005 to 0.010 in order to reduce its relative weight from 79 % to 50 %.

The recommended value is the weighted average of 3.19 h with a final uncertainty of 0.06 h, expanded to include the most precise value of Anthony (1992An19, 3.244 (5) h). The reduced-χ^2 value is 3.5.

2.1 β- Transitions

The maximum energy of the β^- transition in the decay of $^{90}Y^{m} \rightarrow {}^{90}Zr$ has been calculated from the relation:

$$E_{\beta-} = Q(^{90}Y^{m} \rightarrow {}^{90}Zr, \text{ from 2003Au03}) - E_{\text{level in Zr-90}}(\text{from 1997Br34}) = 642.9\ (17)\ \text{keV}.$$

The *log ft* of 9.6 and mean energy of 231.7 (7) keV have been calculated with the LOGFT computer program for the 642-keV unique first forbidden transition.

The 642-keV β^- transition probability is deduced from the ratio I_γ(2319 keV)/ I_γ(479 keV) given by H. C. Griffin (1976Fr16). The value of this ratio has been recalculated by the evaluator with the adopted photon branching ratio (see **5.2 γ-ray Emission**).

2.2 γ Transitions

For the $^{90}Y^{m} \rightarrow {}^{90}Y$ and $^{90}Y^{m} \rightarrow {}^{90}Zr$ branching, the transition probabilities have been calculated using gamma-ray intensities and the internal conversion coefficients (see **5.2 γ-ray emissions**).

Multipolarities of γ-ray transitions in both decays of $^{90}Y^{m}$ are from 1997Br34:
202-keV γ-ray: M1 + E2, δ = -0.04 (4)
479-keV γ-ray: M4 (+ E5)
682-keV γ-ray: E5
2319-keV γ-ray (from $^{90}Y^{m} \rightarrow {}^{90}Zr$): E5

The internal conversion coefficients (ICC's) have been calculated using the Icc99v3a computer program (GETICC dialog). The adopted values have been interpolated from new tables of Band et al.(2002Ba85). The uncertainties of internal conversion coefficients have been estimated as 3 %.

3 Atomic Data

Atomic values are from 1996Sc06.

4 Electron Emissions

The Auger electrons emission probabilities have been calculated from γ-ray and conversion electron data by using the EMISSION computer program. The Auger electrons emission probabilities of ^{90}Zr aren't given in the table file, because they are negligible (of the order of 10^{-7}).

5 Photon Emissions

5.1 X-ray Emissions

The X-ray emission probabilities have been calculated from γ-ray and conversion electron data by using the EMISSION computer program. The X-ray emission probabilities of ^{90}Zr aren't given in the table file, because they are negligible (of the order of 10^{-7}).

5.2 γ-ray Emissions

The relative emission probabilities measured in the isomeric decay of $^{90}Y^{m}$ are given in Table 2. The 479-keV line as been taken as 100 %.

Table 2: Relative γ-ray emission probabilities measured in the isomeric decay of $^{90}Y^{m}$, in %.

Energy (keV)	Heath (1961He09)	Hanser (1973Ha18)	Raman (1973Ra10)	Kluge (1974Kl06)	Griffin (1976Gr17)	Rao (1978Ra05)	Evaluated Values
202.53	104.99 (44)	107.2 (4)	103.7 (33)	none	none	none	106.1 (11)
682.04	< 0.01	none	none	0.40 (8)	0.34 (5)	0.35 (3)	0.352 (24)

For each γ-ray, the evaluated relative γ-ray emission probabilities are weighted averages (calculated with the LWEIGHT computer program, version 3) of the three values measured with uncertainties.

The normalization factor to convert the relative emission probabilities to the absolute emission probabilities has been calculated from the intensity balance at the ^{90}Y ground state. As β^- branching in the ^{90}Y^m is negligible (1976Gr16), the normalization factor is:

$$\text{Normalization factor} = \frac{100\ \%}{[(1 + \alpha_T(202))P_{rel}(202)] + [(1 + \alpha_T(682))P_{rel}(682)]}$$

From the theoretical α_T and the evaluated relative emission probabilities of the 202- and 682-keV γ-rays (Table 2), the normalization factor becomes **0.915 (9) %**. The uncertainty was calculated through the propagation on the formula given above.

The 479-keV transition probability is given by:
$P_{(\gamma+ce)}$(682 keV) + $P_{(\gamma+ce)}$ (479 keV) = 100 %.
Taking into account the evaluated normalization factor, the theoretical α_T and the evaluated relative emission probability of the 682-keV γ-rays (Table 2), then $P_{(\gamma+ce)}$(682 keV) = 0.329 (23) % and, therefore, $P_{(\gamma+ce)}$ (479 keV) = 99.671 (23) %.

The evaluated relative and absolute emission intensities for the 202-, 479- and 682-keV γ-rays are given in Table 3:

Table 3: Evaluated relative and absolute γ-ray emission intensities.

Energy (keV)	Relative emission intensity (%)	Absolute emission intensity (%)
202.53	106.1 (11)	97.1 (14)
479.53	99.4 (10)	90.97 (24)
682.04	0.352 (24)	0.322 (22)

From the 479-keV γ-ray absolute emission intensity value (Table 3) and the value of I_γ(2319 keV)/ I_γ(479 keV) = 2.1 (2) 10^{-5}, as given by Griffin (1976Gr16), then I_γ(2319 keV) = 0.0019 (2) %.

6 References

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