^{89}Sr – Comments on evaluation of decay data by E. Schönfeld

This evaluation was completed by E. Schönfeld (PTB) in November 1999.
The half-life evaluation was up-dated by M.-M. Bé (LNHB) in November 2002.

1 Decay Scheme

Below the *Q*-value there are no other levels of ^{89}Y. Thus, the decay scheme is complete. Spins and parities of the levels and lg *ft* values are taken from Sievers (1989). The half-life of the isomeric level at 909 keV was determined by Yule (1967) to be 16,06(4) s and by Durrani and Köhler (1966) to be 15,91 (17) s. The weighted mean is 16,05 (4) s. Earlier determinations were carried out by Swann and Metzger (1955) and Sattler (1962). The excited levels of ^{89}Y were studied by Robinson *et al.* (1969).

2 Nuclear Data

For the half-life evaluation the following measurements, carried out since 1954, were considered ($T_{1/2}$ in d):

Reference	Value (days)	Uncertainty	Comments
Herrmann (1954)	50,4	0,5	Superseded by the 2nd value
Herrmann and Strassmann (1955)	50,5	0,2	
Kjelberg and Papas (1956)	51	1	Omitted, outlier
Osmond and Overs (1959)	50,36	0,18	
Sattler (1952)	53,6	0,4	Omitted, outlier
Marsden and Yaffee	50		Omitted, no uncertainty
Flynn *et al.*	52,7	0,5	Omitted, outlier
Anspach *et al.* (1965)	50,70	0,19	
Anspach *et al.* (1965)	50,52	0,04	Original uncertainty = 0,03
Baba *et al.* (1971)	50,55	0,09	
Lagoutine *et al.* (1972)	50,75	0,25	Superseded by Amiot
Amiot *et al.* (2003)	50,65	0,05	
Recommended value	**50,57**	**0,03**	Weighted mean

Four values have been omitted from the analysis, the uncertainty on the second Anspach value (Anspach et al., 1965) has been multiplied by 1,33 in order to reduce its relative weight to 50 % in the calculation of the weighted mean and because it seems optimistic when compared with the other data. The set of six values taken into account in this analysis has a reduced-χ^2 of 1,2. Finally, the adopted value (half-life, uncertainty) is the weighted mean and the external uncertainty.

The *Q*-value is taken from Audi and Wapstra (1995).

2.1 b- Transitions

The shape of the unique 1st forbidden β spectrum of ^{89}Sr was measured by Wohn and Talbert (1970). They found the end-point energy to be 1488(4) keV. The shape corrected lg *ft* was calculated by these authors to be 8,36. Earlier, the maximum beta end-point energy was determined to be 1463(5) keV by Bisi et al. (1955). This value is too small compared with the result of Wohn and Talbert and the larger value taken from the compilation of Audi and Wapstra (1995) which is the here adopted one.

Internal bremsstrahlung accompanying the first forbidden beta decay of ^{89}Sr was measured by Babu et al. (1987), Sayibaba et al. (1987), Basha et al. (1991) and Dhaliwal et al. (1994). Sayibaba et al. carried out their measurements with a HPGe detector and a multichannel analyzer along with a standard geometrical set-up. Their results are satisfactorily accounted for by the KUB theory. Basha et al. compared also their measurements with the theoretical spectra. Dhaliwal et al. measured the spectra using an extrapolation procedure with a beta stopper method. Their results are in agreement with the Lewis and Ford theory in the whole energy region covered by the present measurements and do not favour the KUB and Nilsson theories beyond a photon energy of 400 keV.

2.2 Gamma Transition

The energy of the gamma rays following the ^{89}Sr β^- decay was measured by Merritt et al. (1982) to be 909,12(7) keV whereas Sievers gives 908,96(4) keV as unweighted average from several (n,γ)-reactions and from the decay of ^{89}Zr ($T_{1/2}$ = 78,4 h). In the present evaluation 909,0(1) keV is adopted. The transition probability of the gamma transition is calculated from the gamma ray emission probability of the 909 keV transition (see section 4.2) and the conversion coefficient of this transition. The conversion coefficients are interpolated from the tables of Rösel et al. (1978).

3 Atomic Data

The atomic data are taken from Schönfeld and Janßen (1996).

3.1 X Radiation

The energies are based on the wavelengths of Bearden (1967). The relative probabilities are taken from Schönfeld and Janßen (1996).

3.2 Auger Electrons

The energies of the Auger electrons are taken mainly from Larkins (1977). The ratios *P*(KLX)/*P*(KLL) and *P*(KXY)/*P*(KLL)are taken from Schönfeld and Janßen (1996).

4 Radiation Emission

4.1 Electron Emission

The energies and emission probabilities of the β particles correspond to the data given already in Section 2.1. The number of conversion electrons per disintegration has been calculated using the gamma ray emission probability P_γ and the conversion coefficient as given in Section 2.2. The emission probabilities of the Auger electrons have been calculated with the PTB program EMISSION using the atomic data as given in Section 3.

4.2 Photon Emissions

The gamma ray emission intensity, per one disintegration, was found to be:

1	$9{,}71(24)\cdot 10^{-5}$	Merritt et al. (AECL)	1980	replaced by value 3
2	$9{,}65(29)\cdot 10^{-5}$	Hoppes et al. (NBS)	1980	
3	$9{,}54(16)\cdot 10^{-5}$	Merritt et al. (AECL)	1982	
4	$9{,}61(13)\cdot 10^{-5}$	Schötzig (PTB)	1990	
5	$9{,}555(34)\cdot 10^{-5}$	Schima (NIST)	1998	
6	$9{,}56(6)\cdot 10^{-5}$	adopted value	1999	

Value 1 is replaced by value 3, value 6 is the LWM of values 2, 3, 4 and 5. The reduced χ^2 of this set is 0,19.

The emission probabilities of K-X rays are very small. This is caused by the small values of $P_{\gamma + ce}$ and α_K. Lyon and Rickard (1955) were the first who detected these weak gamma rays.

The number of emitted KX rays due to K-shell internal-ionization probabilities in nuclear beta decay were measured in comparison to the absolute beta decay rate by Hansen and Parthasaradhi (1974). Their experimental result is 8,6 (7) 10^{-4} quanta per decay. The contribution of K conversion of the 909 keV γ-transition is only 5,1 10^{-7} per decay.

5 Main Production Modes

The production mode are taken from Sievers (1989).

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