

**²⁵²Cf - Comments on evaluation of decay data
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This evaluation was completed in November 2007. The literature available by October 2007 was included.

1 Decay Scheme

²⁵²Cf disintegrates by α emissions mainly to the ²⁴⁸Cm ground state level, and by spontaneous fission for 3,086 (8) %.

In the Tables part, the data are then normalized to 96,914 (3) alpha decays (see §2.2).

The calculated Q value of 6217 (26) keV deduced from the decay scheme data, for the α decay, is in agreement with the value of 6216,87 (4) keV from Audi *et al.* (2003Au03).

2 Nuclear Data

The Q value is from the atomic mass evaluation of Audi *et al.* (2003Au03).

The level energies, spins and parities are based on the evaluation of Y.A. Akevali (1999Ak02).

2.1 Total half-life

A theoretical calculation of the α -decay half-life of Cf-252, by M. Balasubramaniam *et al.* (1999Ba03) leads to a value of 2,592 a.

The measured half-life are, in years:

Reference	half-life	Uc	Comments
Mehta (1965Me02)	2,646	0,004	
De Volpi (1969De23)	2,621	0,006	Rejected by Chauvenet criterion
Mijnheer (1973Mi05)	2,659	0,010	Rejected by Chauvenet criterion
V.Spiegel (1974Sp02)	2,638	0,007	
V.T. Shchebolev (1974Sh15)	2,628	0,010	Superseded by 1992Sh33
Mozhaev (1976Mo30)	2,637	0,005	
Lagoutine (1982La25)	2,639	0,007	
J.R.Smith (1984SmZW)	2,651	0,003	
W.G.Alberts (1983Al**)	2,648	0,002	
E.J. Axton (1985Ax**)	2,6503	0,0031	
Chen Keliang (1988Ke**)	2,64	0,13	
V.T. Shchebolev (1992Sh33)	2,645	0,003	
Weighted mean	2,6470	0,0014	$\chi^2 = 1,3$; χ^2 crit = 2,5

(See also 1994Ka08, 1994KhZW for previous evaluated values.)

In the set of data listed above, two values were rejected in application of the Chauvenet's criterion. A value from 1974Sh15 has been superseded by a more recent one by the same author (1992Sh33). The remaining set of 9 values is consistent with a reduced χ^2 of 1,3. Then the weighted mean is 2,6470 with an external uncertainty of 0,0014. The largest contribution to the statistical weight (35 %) is from Alberts ; Axton,

Shchebolev and Smith give about 15 % each.

However, in the references listed above the uncertainty budget, in most cases, was not given. Some of them include the statistical part of the uncertainty only and did not take into account the systematic components as the associated presence of Cf-250 for example. So, as recommended in the study of Kharitonov (1994KhZW) an uncertainty of 0,1 % has been applied on the final result.

The adopted value is 2,6470 (26) a.

2.2 Spontaneous fission half-life

The spontaneous fission decay constant λ_{sf} is determined by :

$$\lambda_{sf} = \lambda / [(N\alpha/N_{sf}) + 1]$$

where $(N\alpha/N_{sf})$ is the ratio between the number of α -decays and N_{sf} the number of spontaneous fission events and, λ is the total ²⁵²Cf decay constant.

Measured values of the ratio $N\alpha/N_{sf}$:

Reference	Value	Uc
D.Mehta (1965Me02)	31,3	0,2
B.M.Aleksandrov (1970Al23)	31,39	0,26
J.D.Hastings (1971Ha**)	31,5	0,2
A.K. Pandey (1993Pa29)	31,56	0,35
Y.S.Popov (1990Po24)	31,38	0,12
Weighted mean	31,40	0,08

The 5 data sets given above are consistent (reduced $\chi^2 = 0,2$).

From this value and the total half-life above (§ 2.1), a **spontaneous fission half-life of 85,76 (23) a** is deduced.

From $N\alpha/N_{sf} = 31,40$ (8) and $N\alpha + N_{sf} = 100$ Cf-252 decays, the **percentage of spontaneous fissions in the decay of Cf-252 is 3,086 (8) %**.

Then the percentage of alpha transitions is: 96,914 (8) %.

2.3 Average number of neutrons

The average number of neutrons $\bar{\nu}$ emitted by spontaneous fission is:

$$\bar{\nu} = 3,7675$$
 (40)

as evaluated in the study of M. Divadeenam *et al.* (1984Di08) where relevant experimental data are taken into account and a least-squares fitting program was used to obtain an overall fit.

The average number of neutrons emitted per 100 disintegrations is:

$$n = 3,086$$
 (8) \times $3,7675$ (40) = $11,627$ (33) %

2.4 a Transitions

See Alpha-particle emissions (§ 4)

2.5 g Transitions

Multipolarities of these γ -ray transitions are from 1999Ak02.

The internal conversion coefficients for the 43- and 100-keV gamma transitions were calculated with the BrIcc code for the Frozen Orbital approximation (2005KiZW).

3 Atomic Data

Atomic values, ω_K , ω_L and n_K , are from Schönfeld and Janßen (1996Sc33).

4 α -Particle Emissions

4.1 α -Particle Energies

From the measured values of Rytz (1986Ry04) and Baranov (1976BaZZ, 1971Ba10, 1970Ba18), Rytz (1991Ry01) made some adjustments taking into account variations in the energies used as calibration standards. This leads, for the two main groups, to the recommended values of : 6118,10 (10) keV and 6075,64 (11) keV

The other energies : 5976,6 ; 5826,3 and 5615,6-keV are from Baranov (1970Ba18 and 1971Ba10)

Recorded spectra are also shown in Glover (1984Gl03) and Wiltshire (1985Wi14).

4.2 α -Particle Intensities

Measured alpha intensities, per 100 alpha decays :

Energy (keV)	Reference	Intensity (%)	Uc	Comments
6118,10	Asaro (1955As42)	84,5		
	Baranov (1976BaZZ)	84,1	0,4	See also 1970Ba18
	Adopted	84,3	0,3	Unweighted mean
6075,64	Asaro (1955As42)	15,5		
	Baranov (1976BaZZ)	15,8	0,1	See also 1970Ba18
	Adopted	15,6	0,3	Unweighted mean
5976,6	Baranov (1970Ba18)	0,2		See also 1985Wi14
	Asaro (1958As64)	0,28		
	Adopted	0,24	0,04	Unweighted mean
5826,3	Baranov (1970Ba18)	$2 \cdot 10^{-3}$		
5616	Baranov (1970Ba18)	$\sim 6 \cdot 10^{-5}$		

The number of measurements is very scarce moreover the results given by Asaro are without uncertainties. To try to make the most of this limited data, the unweighted mean is adopted, for the 6118-, 6075-, 5976-keV groups, with uncertainty covering the two existing values.

The intensity of the 5826-keV group is from Baranov (1970Ba18).

The weak group with energy 5615-keV, possibly feeding a 505-keV level, is not adopted, because no photons depopulating this level have been observed in the Cf-252 decay.

In the Tables part, these data are normalized to 96,914 (8) alpha decays (see §2.2).

5 Photon Emissions

5.1 g-Ray Emissions

Measured gamma-ray intensities, per 100 alpha decays :

Energy (keV)	Reference	Intensity (%)	Uc	Comments
42	Asaro (1955As42)	0,014		
43,399 (25)	Watson (1971Wa28)	0,0153	0,0009	
	Adopted	0,0157	0,0004	From decay scheme
100,2 (4)	Asaro (1955As42)	0,013		Adopted E γ (1999Ak02)
	Adopted	0,0123	0,0021	From decay scheme
154,5 (2)	Piercey (1993Pi07)			Adopted E γ (1993Pi07)
	Adopted	0,00053	0,00001	From decay scheme

The gamma ray intensities were deduced from the gamma-ray transition probabilities (see §2.5) and the theoretical ICC values.

In the Tables, these data are normalized to 100 decays of Cf-252 (see §2.2).

5.2 X-ray emissions

Asaro (1955As42) measured a K X-ray intensity of 0,007 %. This value disagrees with an expected KX-ray intensity of 0,000 086 % from the internal conversion electrons of the 154,5-keV gamma ray.

Relative intensities were measured by Popov *et al.* (1990Po14).

Total L X-ray intensity following the Cf-252 decay to Cm-248 was measured by Watson (1971Wa28) as 7,83 (40) % per 100 alpha decays.

The L X-ray total intensity calculated from the decay scheme data is 6,26 (14) % per 100 alpha decays. This result is in reasonable agreement with the measured value of Watson.

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