

¹⁶⁶Ho - Comments on evaluation of decay data by E. Schönfeld and R. Dersch

1 Decay Scheme

Below the Q value of 1854,5 keV there are several other excited levels of ¹⁶⁶Er which are populated in the disintegration of ¹⁶⁶Ho^m ($T_{1/2} = 1200$ a) and ¹⁶⁶Tm ($T_{1/2} = 7,70$ h). Beta transitions from ¹⁶⁶Ho to these levels, if existing, would have high degrees of forbiddenness so that they are not populated in the ¹⁶⁶Ho decay (or with extremely low transition probabilities). Thus, the decay scheme, given on page 1, can be considered as complete. Spins, parities and half-lives of the excited levels, and $lg f_t$ were taken from Ignatovkin et al. (1987).

2 Nuclear Data

Following half-life measurements have been taken into account ($T_{1/2}$ in h):

1	27,5	Inghram and Hayden	1947
2	26,8(4)	Grant and Hill	1949
3	26,9(1)	Cork et al.	1958
4	26,8(2)	Funke et al.	1963
5	26,74(5)	Daniel and Kaschl	1966
6	27,00(4)	Venkata Ramaniah et al.	1976
7	26,827(5)	Abzouzi et al.	1989
8	26,78(1)	Calhoun et al.	1991
9	26,7663(44)	Unterweger et al.	1992
10	26,795(29)	adopted value	1999

Value 1 is only of historical interest. Value 8 is replaced by value 9, value 6 is considered as outlier (or its accuracy is overestimated). The adopted value is the LWM of values 2-5, 7 (with doubled uncertainty to take account for systematical errors) and 9. LWM has used weighted average and expanded the uncertainty so range includes the most precise value 9. The rather large uncertainty reflects the discrepancy between the values 7 and 9.

2.1 β^- Transitions

The maximum beta energy of the transition to the ground state of ¹⁶⁶Er and the transition probability of this transition have been determined as follows:

1	1840	25 %	Sunyar 1954
2	1854(5)	51,6 %	Graham et al. 1955
3	1839(5)	47 %	Cork et al. 1958
4	1844	52 %	Marklund et al. 1960
5	1840	46 %	Cline et al. 1962
6	1859(3)	48,8 %	Funke et al. 1963
7	1857(3)	48,8 %	Daniel and Kaschl 1966
8	1854,7(15)	51,2 %	Grigoriev et al. 1974
9	1845(2)	52 %	Venkata Ramaniah et al. 1976
10	1854,8(17)		weighted average of values 2, 6 - 9 (see text below)
11	1854,5(9)		Audi and Wapstra 1995. Here adopted too

For the calculation of the average value 10, the originally given uncertainty of value 9 has been doubled before inserting it in the averaging procedure because the uncertainty seems to be overestimated. The unweighted average for the transition probability to the ground state (including values 2 to 9) is 49,6 %. This value agrees satisfactorily with the adopted value 48,2(15) % which was derived in the balancing procedure from the gamma transition probabilities.

2.2 Gamma Transitions

The energies of the gamma transitions are calculated from the gamma ray energies (section 4.2) taking the recoil energies into account which can be neglected in most cases. The probabilities P_{g+ce} are calculated from the gamma ray emission probabilities and the total conversion coefficients.

The conversion coefficients are interpolated from the tables of Rösel et al. (1978). Very much work has been spent for the study of the conversion of the 80,57 keV gamma transition. The K conversion coefficient of this transition was found to be

1	1,69(9)	Ramaswamy and Brahmavar	1963
2	1,63(5)	Falkstroem et al.	1968
3	1,72(6)	Nelson and Hatch	1969
4	1,69(6)	Campbell et al.	1971
5	1,66(6)	Campbell et al.	1972
6	1,65(5)	interpolated from Rösel et al.	1978; adopted value

For the K/L ratio the following values were found:

1	0,390(18)	Bogdanovic et al.	1968
2	0,426(11)	Nilsson et al.	1968
3	0,414(13)	Kartashov et al.	1977
4	0,411(12)	interpolated from Rösel et al.	1978; adopted value

Kartashov et al. (1977) have also determined the ratios M/L, N/M and O/N. From their measurements the following set can be derived:

$$\begin{aligned}\alpha_K &= 1,650(33) \\ \alpha_L &= 3,983(170) \\ \alpha_M &= 0,990(50) \\ \alpha_N &= 0,200(12) \\ \alpha_{OP} &= 0,048(3) \\ \alpha_t &= 6,87(18)\end{aligned}$$

The total conversion coefficient of this transition was determined by Brandtley et al. (1966) to be $\alpha = 6,94(48)$. Several other authors have determined L subshell ratios (Hermann et al. (1966), Gelletly et al. (1966, 1967), Karlsson et al. (1966), Zyllicz et al. (1966), Arnoux and Gizon (1967), Bogdanovic et al. (1968)). Also M and N subshell ratios were determined (Hoegberg et al. (1968), Dragoun et al. (1972), Bulgakov et al. (1981)).

The conversion coefficients contained in table 2.2 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 X ray wave lengths compiled by Bearden (1967). The relative probabilities are calculated using the ratios $P(K_{\beta_2})/P(K_{\alpha_1})$ and $P(K_{\beta_1})/P(K_{\alpha_1})$ as given by Schönfeld and Janßen (1996). The relative probability of X_L radiation is calculated from the absolute value putting $P(K_{\alpha_1}) = 100$.

3.2 Auger Electrons

The energies are taken mainly from the report of Larkins (1977). The relative probabilities are calculated using the ratios $P(KLX)/P(KLL)$ and $P(KXY)/P(KLL)$ as given in the cited report of Schönfeld and Janßen (1995). The relative probability of e_{AL} electrons is calculated from the absolute value putting $P(KLL) = 100$.

4 Radiation Emission

4.1 Electron Emission

The numbers of Auger electrons per disintegration are calculated using the program EMISSION and the atomic data as given in Section 3. The numbers of conversion electrons per disintegration are calculated using the conversion coefficients and the probabilities $P_{\gamma+ce}$ as given in 2.2. Spectra of the conversion electrons from the 80,6 keV

transition, the 1379,4 keV transition and the $0^+ \rightarrow 0^+$ 1460 keV E0 transition were measured by Grigoriev et al. (1974). The data for the emission of β particles are those already given in 2.1.

4.2 Photon Emission

Most of the gamma-ray energies were taken from Ardisson et al. (1992) ($\gamma_{1,0}$, $\gamma_{4,3}$, $\gamma_{3,1}$, $\gamma_{3,0}$, $\gamma_{4,1}$, $\gamma_{5,0}$, $\gamma_{6,1}$, $\gamma_{6,0}$, $\gamma_{8,1}$, $\gamma_{7,0}$, $\gamma_{8,0}$).

The following measurements of relative photon emission probabilities have been taken into account (the relative emission probability of the 1379,4 keV line was arbitrarily set to 1):

E in keV	1	2	3	4	5	6	7
80,6	6,67(43)	-	7,04(30)	6,72(70)	7,22(8)	6,56(40)	7,02(14)
184,4	-	0,0022(5)	-	0,0013(3)	0,0023(1)	0,0010(1)	0,0016(7)
521,0	-	-	-	0,00032(11)	0,0005(2)	0,00038(1)	0,00038(2)
674,2	0,032(2)	0,022(2)	0,034(2)	0,0176(9)	0,023(1)	0,0201(4)**	0,0212(18)
705,4	0,020(3)	0,016(2)	0,023(1)	0,0137(7)	0,0170(10)	0,0144(3)**	0,0156(13)
785,9	0,016(3)	0,014(2)	0,012(5)	0,0125(7)	0,0140(10)	0,0128(3)**	0,01288(27)
1263,0	-	-	-	0,0015(2)	0,0017(1)	0,0016(3)	0,00166(9)
1379,4	1	1	1	1	1	1	1
1447,5	-	-	-	0,00105(10)	0,0012(1)	0,0014(5)	0,00113(10)
1528,2	-	-	-	0,0002	-	0,00010(1)	0,00015(5)
1581,8	0,206(10)	0,195(10)	0,215(10)*	0,197(7)	0,199(5)	0,197(5)	0,1994(28)
1662,4	0,129(7)	0,125(6)	0,099(5)*	0,130(5)	0,127(4)	0,130(2)**	0,126(5)
1731,5	-	-	-	-	-	0,00005(2)	0,00005(2)
1749,8	0,033(1)*	0,027(2)	0,030(17)	0,028(2)	0,028(1)	0,0285(6)**	0,0292(9)
1812,8	-	-	-	-	-	0,00006(2)	0,00006(2)
1830,5	0,0100(8)*	0,0086(11)	0,0081(5)	0,0089(5)	0,0085(2)	0,0089(3)	0,0087(2)

1 Burson et al. 1967

2 Reich and Cline 1970

3 Venkata Ramaniah et al. 1976

4 Allab et al. 1977

5 Chand et al. 1989

6 Ardisson et al. 1992

7 values adopted in this evaluation (LWM)

* classified as outlier (appearing only in values of references 1 and 3)

** input uncertainty slightly increased (only for some values of reference 6 and one value of reference 5)

Earlier results of Marklund et al. (1960), Hansen et al. (1961), Cline et al. (1962), Funke et al. (1963) and Neumann (1966) were not taken into account because they are less accurate, incomplete and given without uncertainties.

The absolute emission probability for the gamma rays from the transition $\gamma_{1,0}$ (80,6 keV) has been determined as follows (gamma rays per 100 disintegrations):

1	6,55(30)	Venkata Ramaniah et al. 1976
2	6,25(60)	Allab et al. 1977
3	6,60(40)	Sekine and Baba 1981
4	6,55(8)	Calhoun et al. 1991; Coursey et al. 1994

In the present evaluation value 4 is adopted. Combining it with the relative emission probability of the 80,6 keV transition, the normalization factor 0,933(16) is obtained.

5 Main Production Modes

Taken from Firestone (1995).

6 References

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Other references can be found in the Tables Part.