

$^{232}\text{Ac} \beta^-$  decay 1986Gi08

| Type            | Author    | History Citation     | Literature Cutoff Date |
|-----------------|-----------|----------------------|------------------------|
| Full Evaluation | E. Browne | NDS 107, 2579 (2006) | 1-Nov-2004             |

Parent:  $^{232}\text{Ac}$ : E=0;  $J^\pi=(1^+)$ ;  $T_{1/2}=119$  s 5;  $Q(\beta^-)=3700$  SY;  $\% \beta^-$  decay=100.0

Natural tungsten bombarded with 2713-MeV  $^{238}\text{U}$  beam;  $\alpha=232$  selected by on-line mass separator; measured  $\gamma$  rays with a Ge(Li) detector,  $\beta^-$  particles with a  $4\pi$  scin (1986Gi08); earlier results of 1973Ch24 (reporting  $T_{1/2}=35$  s) were not confirmed.

The decay scheme is based mainly on 1986Gi08, except as noted. The levels at 1437, 1642, 1880, 1948, 1978, and 2008 are proposed by 1986Gi08 solely on the basis of  $E_\gamma$  differences of two deexciting  $\gamma$  rays per level. The  $I_\gamma$  division for the 612.0 and 724.8 doublets is based on light-ion Coul. ex. results for the deexcitation of the 774-keV doublet (1986Gi08 ignored any feeding to the  $J^\pi=3^-$  774.4-keV level).

$^{232}\text{Th}$  Levels

| E(level) | $J^\pi$ † | E(level) | $J^\pi$ † | E(level) | $J^\pi$ † | E(level) | $J^\pi$ † |
|----------|-----------|----------|-----------|----------|-----------|----------|-----------|
| 0        | $0^+$     | 774.3    | $3^-$     | 1105.7   | $3^-$     | 1948?‡   | $(1,2^+)$ |
| 49.4     | $2^+$     | 785.2    | $2^+$     | 1122.8   | $(2^+)$   | 1978?‡   | $(2^+)$   |
| 162.1    | $4^+$     | 1072.9   | $2^+$     | 1437?‡   | $(1,2^+)$ | 2008?‡   | $(1,2^+)$ |
| 714.3    | $1^-$     | 1077.5   | $(1^-)$   | 1641.8?‡ | $(1,2^+)$ |          |           |
| 774.1    | $2^+$     | 1078.7   | $(0^+)$   | 1880?‡   | $(1,2^+)$ |          |           |

† For levels up to 1437 keV  $J^\pi$  are from Adopted Levels.  $J^\pi$  for questionable levels >1437 keV are from  $\gamma$ -ray deexcitation.

‡ Level not adopted.

$\beta^-$  radiations

| E(decay)    | E(level) | $I\beta^-$ † | Log $ft$             | Comments           |
|-------------|----------|--------------|----------------------|--------------------|
| (1692?‡ SY) | 2008?    | 9 1          | 6.32 6               | av $E\beta=$ 631.5 |
| (1722?‡ SY) | 1978?    | 6 1          | 6.53 8               | av $E\beta=$ 643.6 |
| (1752?‡ SY) | 1948?    | 14 1         | 6.19 4               | av $E\beta=$ 655.7 |
| (1820?‡ SY) | 1880?    | 6 1          | 6.61 8               | av $E\beta=$ 683.2 |
| (2058?‡ SY) | 1641.8?  | 6 2          | 6.80 15              | av $E\beta=$ 780.4 |
| (2263?‡ SY) | 1437?    | 4.9 9        | 7.04 9               | av $E\beta=$ 864.7 |
| (2577 SY)   | 1122.8   | 5.2 9        | 7.22 8               | av $E\beta=$ 995.1 |
| (2594 SY)   | 1105.7   | 1.1 2        | 9.18 <sup>1u</sup> 9 | av $E\beta=$ 960.9 |
| (2621?‡ SY) | 1078.7   | 1.2 8        | 7.9 3                | av $E\beta=$ 1013  |
| (2622 SY)   | 1077.5   | 2.1 5        | 7.64 11              | av $E\beta=$ 1014  |
| (2627?‡ SY) | 1072.9   | 2.0 10       | 7.67 22              | av $E\beta=$ 1016  |
| (2914 SY)   | 785.2    | 3.9 6        | 7.55 7               | av $E\beta=$ 1141  |
| (2925 SY)   | 774.3    | 5.3 5        | 8.79 <sup>1u</sup> 5 | av $E\beta=$ 1097  |
| (2925?‡ SY) | 774.1    | 0.7 3        | 8.30 19              | av $E\beta=$ 1141  |
| (2985 SY)   | 714.3    | 18.2 9       | 6.92 3               | av $E\beta=$ 1166  |
| (3650?‡ SY) | 49.4     |              | >7.4                 |                    |
| (3700 SY)   | 0        | 15 3         | 7.35 9               | av $E\beta=$ 1466  |

$I\beta^-$ : sum of  $I\beta$  to g.s. and to 49.3 level, based on  $I(\gamma+ce)$  intensity balance. The log  $ft$  value is based on the assumption that  $I\beta$  feeds just the g.s.

† Absolute intensity per 100 decays.

‡ Existence of this branch is questionable.

γ(<sup>232</sup>Th)

I<sub>γ</sub> normalization: From **1986Gi08** based on βγ coin measurements.  
I(K x ray)/I<sub>γ</sub>(665.0)=0.34 5 (**1986Gi08**).

| E <sub>γ</sub> | I <sub>γ</sub> <sup>#</sup> | E <sub>i</sub> (level) | J <sub>i</sub> <sup>π</sup> | E <sub>f</sub> | J <sub>f</sub> <sup>π</sup> | Mult. <sup>†</sup> | δ     | α <sup>@</sup> | I <sub>(γ+ce)</sub> <sup>#</sup> | Comments   |
|----------------|-----------------------------|------------------------|-----------------------------|----------------|-----------------------------|--------------------|-------|----------------|----------------------------------|--|
| (49.369 9)     |                             | 49.4                   | 2 <sup>+</sup>              | 0              | 0 <sup>+</sup>              | E2                 |       | 332            |                                  | α(L)= 243.9; α(M)= 66.4<br>E <sub>γ</sub> : from <sup>236</sup> U α decay.   |
| 112.7 1        | 6 1                         | 162.1                  | 4 <sup>+</sup>              | 49.4           | 2 <sup>+</sup>              | E2                 |       | 6.84           |                                  | α(K)= 0.2333; α(L)= 4.79; α(M)= 1.317; α(N+..)= 0.491  |
| 612.0 3        | 1.5 <sup>‡</sup> 9          | 774.1                  | 2 <sup>+</sup>              | 162.1          | 4 <sup>+</sup>              | [E2]               |       | 0.0273         |                                  | α(K)=0.01869; α(L)=0.00646<br>I <sub>γ</sub> : calculated from I <sub>γ</sub> (612)/I <sub>γ</sub> (774)≠0.60 in light-ion Coul. ex.   |
| (612.0 3)      | 33 <sup>‡</sup> 3           | 774.3                  | 3 <sup>-</sup>              | 162.1          | 4 <sup>+</sup>              | [E1]               |       | 0.00854        |                                  | α(K)=0.00695; α(L)=0.00120<br>I <sub>γ</sub> : from light-ion Coul. ex. and I <sub>γ</sub> (774.1 γ) most of the 612.0-keV I <sub>γ</sub> intensity deexcites the 774.4-keV jp=3 <sup>-</sup> state, and not the 774.1- keV J <sup>π</sup> =2 <sup>+</sup> state as suggested by <b>1986Gi08</b> . |
| 665.0 3        | 100 5                       | 714.3                  | 1 <sup>-</sup>              | 49.4           | 2 <sup>+</sup>              | [E1]               |       | 0.00729        |                                  | α(K)=0.00594; α(L)=0.00102   |
| 714.4 3        | 18 3                        | 714.3                  | 1 <sup>-</sup>              | 0              | 0 <sup>+</sup>              | [E1]               |       | 0.00637        |                                  | α(K)=0.00520; α(L)=0.00088   |
| (724.7 2)      | <sup>‡</sup>                | 774.1                  | 2 <sup>+</sup>              | 49.4           | 2 <sup>+</sup>              | E0+E2              |       |                | ≈0.8                             |  |
| 724.8          | ≈2.9 <sup>‡</sup>           | 774.3                  | 3 <sup>-</sup>              | 49.4           | 2 <sup>+</sup>              | [E1]               |       | 0.00620        |                                  | α(K)=0.00506; α(L)=0.00086<br>I <sub>γ</sub> : from light-ion Coul. ex. From spectra of <b>1986Gi08</b> we estimate I <sub>γ</sub> <5.   |
| 735.8 4        | 16 3                        | 785.2                  | 2 <sup>+</sup>              | 49.4           | 2 <sup>+</sup>              | E2+M1              | 23 10 | 0.019          |                                  | α(K)=0.014; α(L)=0.0037  |
| 774.1 4        | 2.5 15                      | 774.1                  | 2 <sup>+</sup>              | 0              | 0 <sup>+</sup>              | [E2]               |       | 0.01667        |                                  | α(K)=0.01216; α(L)=0.00339   |
| 785.2 4        | 9 2                         | 785.2                  | 2 <sup>+</sup>              | 0              | 0 <sup>+</sup>              | E2                 |       | 0.01620        |                                  | α(K)=0.01185; α(L)=0.00327   |
| 960.6 5        | 6 4                         | 1122.8                 | (2 <sup>+</sup> )           | 162.1          | 4 <sup>+</sup>              |                    |       |                |                                  |  |
| 1023.5 5       | 13 6                        | 1072.9                 | 2 <sup>+</sup>              | 49.4           | 2 <sup>+</sup>              | [E2+M1]            |       | 0.02 1         |                                  |  |
| 1028.1 5       | 8 5                         | 1078.7                 | (0 <sup>+</sup> )           | 49.4           | 2 <sup>+</sup>              | [E2]               |       | 0.00958        |                                  | α(K)=0.00734; α(L)=0.00169<br>Placement based on (n,n'γ). <b>1986Gi08</b> place it from the 1077.5-keV level.  |
| 1056.3 5       | 7 1                         | 1105.7                 | 3 <sup>-</sup>              | 49.4           | 2 <sup>+</sup>              | E1                 |       | 0.00315        |                                  | α(K)=0.00258; α(L)=0.00043<br>Placement from (n,n'γ) and heavy-ion Coul. ex. <b>1986Gi08</b> place it from the 1072.9-keV level.   |
| 1072.9 5       | 28 4                        | 1122.8                 | (2 <sup>+</sup> )           | 49.4           | 2 <sup>+</sup>              |                    |       |                |                                  |  |
| 1077.5 5       | 14 3                        | 1077.5                 | (1 <sup>-</sup> )           | 0              | 0 <sup>+</sup>              | [E1]               |       | 0.00304        |                                  | α(K)=0.00250; α(L)=0.00041   |
| 1388 1         | 22 4                        | 1437?                  | (1,2 <sup>+</sup> )         | 49.4           | 2 <sup>+</sup>              |                    |       |                |                                  |  |
| 1437 1         | 10 4                        | 1437?                  | (1,2 <sup>+</sup> )         | 0              | 0 <sup>+</sup>              |                    |       |                |                                  |  |
| 1593 1         | 16 5                        | 1641.8?                | (1,2 <sup>+</sup> )         | 49.4           | 2 <sup>+</sup>              |                    |       |                |                                  |  |
| 1642 1         | 23 10                       | 1641.8?                | (1,2 <sup>+</sup> )         | 0              | 0 <sup>+</sup>              |                    |       |                |                                  | <a href="#">Additional information 1.</a>  |
| 1815 1         | 13 4                        | 1978?                  | (2 <sup>+</sup> )           | 162.1          | 4 <sup>+</sup>              |                    |       |                |                                  |  |
| 1830 1         | 30 5                        | 1880?                  | (1,2 <sup>+</sup> )         | 49.4           | 2 <sup>+</sup>              |                    |       |                |                                  |  |
| 1880 1         | 9 3                         | 1880?                  | (1,2 <sup>+</sup> )         | 0              | 0 <sup>+</sup>              |                    |       |                |                                  |  |

$^{232}\text{Ac}$   $\beta^-$  decay 1986Gi08 (continued)

$\gamma(^{232}\text{Th})$  (continued)

| <u><math>E_\gamma</math></u> | <u><math>I_\gamma^\#</math></u> | <u><math>E_i(\text{level})</math></u> | <u><math>J_i^\pi</math></u> | <u><math>E_f</math></u> | <u><math>J_f^\pi</math></u> |
|------------------------------|---------------------------------|---------------------------------------|-----------------------------|-------------------------|-----------------------------|
| 1899 2                       | 58 5                            | 1948?                                 | (1,2 <sup>+</sup> )         | 49.4                    | 2 <sup>+</sup>              |
| 1948 2                       | 34 5                            | 1948?                                 | (1,2 <sup>+</sup> )         | 0                       | 0 <sup>+</sup>              |
| 1959 2                       | 35 5                            | 2008?                                 | (1,2 <sup>+</sup> )         | 49.4                    | 2 <sup>+</sup>              |
| 1978 2                       | 25 5                            | 1978?                                 | (2 <sup>+</sup> )           | 0                       | 0 <sup>+</sup>              |
| 2008 2                       | 24 6                            | 2008?                                 | (1,2 <sup>+</sup> )         | 0                       | 0 <sup>+</sup>              |

† From Adopted Levels, Gammas.

‡ Based on light-ion Coulomb excitation.

# For absolute intensity per 100 decays, multiply by 0.153.

@ Total theoretical internal conversion coefficients, calculated using the BrIcc code (2008Ki07) with Frozen orbital approximation based on  $\gamma$ -ray energies, assigned multiplicities, and mixing ratios, unless otherwise specified.

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## Decay Scheme

Intensities:  $I_{(\gamma+ce)}$  per 100 parent decays

## Legend

- $I_\gamma < 2\% \times I_\gamma^{max}$
- $I_\gamma < 10\% \times I_\gamma^{max}$
- $I_\gamma > 10\% \times I_\gamma^{max}$
- - -  $\gamma$  Decay (Uncertain)

