

$^{248}\text{Cm}, ^{252}\text{Cf}$ SF decay [2019Ur01,2019Ur02](#)

| Type | Author | History | Citation | Literature Cutoff Date |
|--------|---------------------------|---------|----------|------------------------|
| Update | Balraj Singh and Jun Chen | | ENSDF | 12-Dec-2022 |

Parent: ^{248}Cm : $E=0.0$; $J^\pi=0^+$; $T_{1/2}=3.48 \times 10^5$ y 6; %SF decay=8.39 16

Parent: ^{252}Cf : $E=0.0$; $J^\pi=0^+$; $T_{1/2}=2.645$ y 8; %SF decay=3.092 8

$^{248}\text{Cm}(0.0)$ -%SF decay: %SF=8.39 16 for SF decay of ^{248}Cm (from ^{248}Cm Adopted Levels in the ENSDF database).

$^{252}\text{Cf}(0.0)$ -%SF decay: %SF=3.092 8 for SF decay of ^{252}Cf (from ^{252}Cf Adopted Levels in the ENSDF database).

[2019Ur01](#), [2019Ur02](#): measured E_γ , I_γ , multi-fold $\gamma\gamma$ -coin, and $\gamma\gamma(\theta)$ using Eurogam2 array at Institut Laue-Langevin (ILL), Grenoble for prompt γ rays from ^{248}Cm SF decay, and Gammasphere array at Argonne National Laboratory for prompt γ rays from ^{252}Cf SF decay. Combined decay scheme is presented by the authors from both the decays.

^{100}Zr Levels

An 1196, (2⁺) level with 318, 632, 865, 984 and 1196 gamma rays from this level is shown in level-scheme figures in [2019Ur01](#) and [2019Ur02](#) for the purpose of discussion only. This level is omitted here as it is not populated in SF decay.

| E(level) [†] | J^π [‡] | Comments |
|-----------------------------|----------------------|---|
| 0.0 [#] | 0 ⁺ | |
| 212.67 [#] 3 | 2 ⁺ | |
| 331.32 [@] 6 | 0 ⁺ | |
| 564.65 [#] 4 | 4 ⁺ | |
| 878.86 [@] 5 | 2 ⁺ | |
| 1061.96 [#] 6 | 6 ⁺ | |
| 1398.32 ^b 8 | (3 ⁺) | |
| 1414.93 [@] 5 | 4 ⁺ | |
| 1687.51 [#] 7 | 8 ⁺ | |
| 1856.21 ^b 7 | 4 ⁺ | J^π : from (1291.6 γ)(351.99 γ +212.67 γ)(θ), where no solution for $\delta(1291.6\gamma$ to 4 ⁺) was obtained for J(1856 level)=3 or 5 (2019Ur02). |
| 1961.96 [@] 6 | 6 ⁺ | A tentative 1397 γ in ^{252}Cf SF decay (2006Hw04 , and Erratum published in Phys. Rev. C 106, 069901(E) (2022)) is not confirmed by 2019Ur02 . |
| 2130.62 ^{&} 9 | 5 ⁽⁺⁾ | |
| 2208.49 ^b 8 | (5 ⁺) | J^π : (1643.8 γ)(351.99 γ)(θ) allows J=4,5,6 (2019Ur02). |
| 2244.71 ^a 10 | 4 ⁺ | J^π : from (1680.0 γ)(351.99 γ +212.67 γ)(θ), where no solution for $\delta(1680.0\gamma$ to 4 ⁺) was obtained for J(2245)=5 or 6 (2019Ur02). |
| 2426.50 [#] 12 | 10 ⁺ | |
| 2471.89 ^b 12 | (6 ⁺) | |
| 2526.20 ^{&} 7 | 7 ⁽⁺⁾ | |
| 2579.64 [@] 7 | (8 ⁺) | |
| 2609.66 ^a 11 | (6 ⁺) | |
| 2776.18 ^b 10 | (7 ⁺) | |
| 3019.74 ^{&} 7 | 9 ⁽⁺⁾ | |
| 3100.36 ^a 15 | (8 ⁺) | |
| 3268.20 [#] 23 | (12 ⁺) | |
| 3289.22 [@] 23 | (10 ⁺) | |
| 3635.55 ^{&} 12 | (11 ⁺) | |
| 3747.46 ^a 25 | (10 ⁺) | |
| 4377.2 ^{&} 5 | (13 ⁺) | |

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$^{248}\text{Cm}, ^{252}\text{Cf}$ SF decay **2019Ur01,2019Ur02 (continued)**

^{100}Zr Levels (continued)

† From least-squares fit to E_γ data.

‡ As given in level-scheme Figs. 1 in **2019Ur01** and **2019Ur02**, based on previous assignments, $\gamma\gamma(\theta)$ data in this work, and band associations. Assignments are the same in the Adopted Levels, except that some are in parentheses in Adopted Levels due to lack of strong supporting arguments.

Band(A): g.s. band.

@ Band(B): Band based on excited 0^+ .

& Band(C): Band based on $5^{(+)}$ state.

^a Band(D): Band based on 4^+ state.

^b Seq.(E): γ cascade based on (3^+) .

$\gamma(^{100}\text{Zr})$

$\gamma\gamma(\theta)$ data and associated A_2, A_4 coefficients are from ^{252}Cf SF decay study using Gammasphere array, unless otherwise specified.

| E_γ | I_γ | $E_i(\text{level})$ | J_i^π | E_f | J_f^π | Mult. | Comments |
|------------|------------|---------------------|--------------------|---------|-------------------|-------|--|
| 118.65† 5 | 1.3† 2 | 331.32 | 0 ⁺ | 212.67 | 2 ⁺ | | |
| 212.67 3 | 100 4 | 212.67 | 2 ⁺ | 0.0 | 0 ⁺ | Q | E_γ, I_γ : same values in 2019Ur01 and 2019Ur02 . |
| 304.5‡ 3 | 0.2‡ 1 | 2776.18 | (7 ⁺) | 2471.89 | (6 ⁺) | | |
| 351.99† 3 | 88† 3 | 564.65 | 4 ⁺ | 212.67 | 2 ⁺ | Q | (351.99 γ)(212.67 γ)(θ): $A_2=+0.100$ 7, $A_4=+0.010$ 9 (2019Ur01), consistent with $4 \rightarrow 2 \rightarrow 0$ spin sequence. |
| 352.3‡ 3 | 0.4‡ 2 | 2208.49 | (5 ⁺) | 1856.21 | 4 ⁺ | | |
| 364.9‡ 1 | 0.6‡ 2 | 2609.66 | (6 ⁺) | 2244.71 | 4 ⁺ | | |
| 395.6† 1 | 0.2† 1 | 2526.20 | 7 ⁽⁺⁾ | 2130.62 | 5 ⁽⁺⁾ | | |
| 440.15† 7 | 0.4† 1 | 3019.74 | 9 ⁽⁺⁾ | 2579.64 | (8 ⁺) | | |
| 441.0 3 | 0.3 1 | 1856.21 | 4 ⁺ | 1414.93 | 4 ⁺ | | E_γ, I_γ : from 2019Ur02 in ^{248}Cm SF decay. |
| 457.7‡ 2 | 0.7‡ 2 | 1856.21 | 4 ⁺ | 1398.32 | (3 ⁺) | | |
| 479.0‡ 2 | 0.7‡ 2 | 2609.66 | (6 ⁺) | 2130.62 | 5 ⁽⁺⁾ | | |
| 490.7‡ 1 | 0.9‡ 3 | 3100.36 | (8 ⁺) | 2609.66 | (6 ⁺) | | |
| 493.55† 5 | 1.3† 2 | 3019.74 | 9 ⁽⁺⁾ | 2526.20 | 7 ⁽⁺⁾ | | |
| 497.36† 5 | 60† 3 | 1061.96 | 6 ⁺ | 564.65 | 4 ⁺ | Q | (497.36 γ)(351.99 γ)(θ): $A_2=+0.107$ 7, $A_4=+0.010$ 10 (2019Ur01), consistent with $6 \rightarrow 4 \rightarrow 2$ spin sequence. |
| 536.05† 5 | 3.2† 3 | 1414.93 | 4 ⁺ | 878.86 | 2 ⁺ | | |
| 547.00† 5 | 2.8† 3 | 1961.96 | 6 ⁺ | 1414.93 | 4 ⁺ | | |
| 547.5† 1 | 1.0† 2 | 878.86 | 2 ⁺ | 331.32 | 0 ⁺ | | |
| 564.2† 1 | 0.9† 2 | 2526.20 | 7 ⁽⁺⁾ | 1961.96 | 6 ⁺ | | |
| 567.2‡ 2 | 0.4‡ 2 | 2776.18 | (7 ⁺) | 2208.49 | (5 ⁺) | | |
| 615.7‡ 2 | 0.2‡ 1 | 2471.89 | (6 ⁺) | 1856.21 | 4 ⁺ | | |
| 615.8† 1 | 0.4† 2 | 3635.55 | (11 ⁺) | 3019.74 | 9 ⁽⁺⁾ | | |
| 617.65† 8 | 1.4† 2 | 2579.64 | (8 ⁺) | 1961.96 | 6 ⁺ | | |
| 625.55† 5 | 27† 3 | 1687.51 | 8 ⁺ | 1061.96 | 6 ⁺ | Q | (625.55 γ)(497.36 γ)(θ): $A_2=+0.111$ 11, $A_4=+0.009$ 16 (2019Ur01), consistent with $8 \rightarrow 6 \rightarrow 4$ spin sequence. |
| 647.1‡ 2 | 0.4‡ 2 | 3747.46 | (10 ⁺) | 3100.36 | (8 ⁺) | | |
| 666.23† 7 | 2.9† 3 | 878.86 | 2 ⁺ | 212.67 | 2 ⁺ | | |
| 709.5† 3 | 0.7† 2 | 3289.22 | (10 ⁺) | 2579.64 | (8 ⁺) | | |
| 715.6† 2 | 0.5† 2 | 2130.62 | 5 ⁽⁺⁾ | 1414.93 | 4 ⁺ | | |

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$^{248}\text{Cm}, ^{252}\text{Cf}$ SF decay **2019Ur01,2019Ur02** (continued) $\gamma(^{100}\text{Zr})$ (continued)

| E_γ | I_γ | $E_i(\text{level})$ | J_i^π | E_f | J_f^π | Mult. | δ | Comments |
|----------------------|------------------|---------------------|------------|---------|------------|---------|----------|---|
| 739.0 \dagger 1 | 15 \ddagger 3 | 2426.50 | 10 $^+$ | 1687.51 | 8 $^+$ | Q | | (739.0 γ)(497.36 γ)(θ): $A_2=+0.107$ 17, $A_4=+0.003$ 25 (2019Ur01), consistent with 10 \rightarrow 8 \rightarrow 6 spin sequence. |
| 741.6 \ddagger 4 | 0.2 \ddagger 1 | 4377.2 | (13 $^+$) | 3635.55 | (11 $^+$) | | | |
| 793.4 \ddagger 2 | 1.0 \ddagger 2 | 2208.49 | (5 $^+$) | 1414.93 | 4 $^+$ | | | |
| 810.1 \ddagger 1 | 1.3 \ddagger 3 | 2208.49 | (5 $^+$) | 1398.32 | (3 $^+$) | | | |
| 833.4 \ddagger 2 | 0.4 \ddagger 1 | 1398.32 | (3 $^+$) | 564.65 | 4 $^+$ | | | |
| 841.7 \ddagger 2 | 8 \ddagger 2 | 3268.20 | (12 $^+$) | 2426.50 | 10 $^+$ | | | |
| 850.24 \ddagger 5 | 5.1 \ddagger 5 | 1414.93 | 4 $^+$ | 564.65 | 4 $^+$ | (M1+E2) | +0.99 6 | (850.24 γ)(351.99 γ +212.67 γ)(θ): $A_2=-0.109$ 9, $A_4=+0.080$ 14 (2019Ur01), consistent with 4 \rightarrow 4 \rightarrow 2 spin sequence, with no solution for δ for 5 \rightarrow 4 \rightarrow 2 and 6 \rightarrow 4 \rightarrow 2 spin sequences. δ : from $\gamma\gamma(\theta)$ (2019Ur01) for J(1415 level)=4, no δ solution for J(1415 level)=5 or 6. |
| 862.8 \ddagger 3 | 0.2 \ddagger 1 | 3289.22 | (10 $^+$) | 2426.50 | 10 $^+$ | | | |
| 878.8 \ddagger 1 | 1.4 \ddagger 2 | 878.86 | 2 $^+$ | 0.0 | 0 $^+$ | | | |
| 892.15 \ddagger 5 | 1.0 \ddagger 3 | 2579.64 | (8 $^+$) | 1687.51 | 8 $^+$ | | | |
| 900.00 \ddagger 5 | 2.5 \ddagger 3 | 1961.96 | 6 $^+$ | 1061.96 | 6 $^+$ | (M1+E2) | +0.74 7 | (900.00 γ)(497.36 γ +351.99 γ +212.67 γ)(θ): $A_2=-0.017$ 15, $A_4=+0.026$ 21 (2019Ur01), consistent with 6 \rightarrow 6 \rightarrow 4 and 7 \rightarrow 6 \rightarrow 4 spin sequences, with no δ solution for 8 \rightarrow 6 \rightarrow 4. δ : +0.74 7 for J(1962 level)=6 and +0.09 3 for J(1962 level)=7 from $\gamma\gamma(\theta)$ (2019Ur01), no δ solution for J(1962 level)=8. |
| 977.4 \ddagger 1 | 0.9 \ddagger 2 | 1856.21 | 4 $^+$ | 878.86 | 2 $^+$ | | | |
| 1185.6 1 | 1.7 3 | 1398.32 | (3 $^+$) | 212.67 | 2 $^+$ | | | E_γ, I_γ : from 2019Ur02 in ^{248}Cm SF decay. |
| 1202.2 \ddagger 2 | 0.6 \ddagger 2 | 1414.93 | 4 $^+$ | 212.67 | 2 $^+$ | | | |
| 1209.1 \ddagger 3 | 0.4 \ddagger 2 | 3635.55 | (11 $^+$) | 2426.50 | 10 $^+$ | | | |
| 1291.6 \ddagger 1 | 1.8 \ddagger 2 | 1856.21 | 4 $^+$ | 564.65 | 4 $^+$ | (M1+E2) | -2.8 7 | (1291.6 γ)(351.99 γ +212.67 γ)(θ): $A_2=+0.018$ 33, $A_4=+0.186$ 46 (2019Ur02) consistent with 4 \rightarrow 4 \rightarrow 2 spin sequence. δ : for J(1856 level)=4, no δ solution obtained for J(1856 level)=3 or 5 (2019Ur02). |
| 1332.15 \ddagger 7 | 2.5 \ddagger 5 | 3019.74 | 9 $^{(+)}$ | 1687.51 | 8 $^+$ | D(+Q) | +0.02 5 | (1332.15 γ)(625.55 γ +497.36 γ +351.99 γ +212.67 γ)(θ): $A_2=-0.086$ 31, $A_4=-0.023$ 47 (2019Ur01), consistent with 9 \rightarrow 8 \rightarrow 6, with no δ solution for 8 \rightarrow 8 \rightarrow 6 and 10 \rightarrow 8 \rightarrow 6. δ : from $\gamma\gamma(\theta)$ (2019Ur01) for J(3020 level)=9, no δ solution for J(3020 level)=8 or 10. |
| 1409.7 \ddagger 2 | 0.5 \ddagger 2 | 2471.89 | (6 $^+$) | 1061.96 | 6 $^+$ | | | |
| 1464.25 \ddagger 7 | 2.0 \ddagger 3 | 2526.20 | 7 $^{(+)}$ | 1061.96 | 6 $^+$ | D(+Q) | +0.02 3 | δ : +0.92 12 for J(2526 level)=6 and +0.02 3 for J(2526 level)=7 from $\gamma\gamma(\theta)$ |

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$^{248}\text{Cm}, ^{252}\text{Cf}$ SF decay **2019Ur01,2019Ur02** (continued)

| $\gamma(^{100}\text{Zr})$ (continued) | | | | | | | | |
|---------------------------------------|---------------------|---------------------|-------------------|---------|----------------|---------|----------|---|
| E_γ | I_γ | $E_i(\text{level})$ | J_i^π | E_f | J_f^π | Mult. | δ | Comments |
| | | | | | | | | (2019Ur01), no δ solution for J(2526 level)=8 from ^{252}Cf SF decay; +0.84 10 for J(2526 level)=6 and +0.05 3 for J(2526 level)=7 from $\gamma\gamma(\theta)$ (2019Ur01), no δ solution for J(2526 level)=8 from ^{248}Cm SF decay. (1464.25 γ)(497.36 γ +351.99 γ +212.67 γ)(θ): $A_2=-0.057$ 19, $A_4=+0.014$ 30 (2019Ur01), consistent with 6 \rightarrow 6 \rightarrow 4 and 7 \rightarrow 6 \rightarrow 4 spin sequences, with no δ solution for 8 \rightarrow 6 \rightarrow 4. (1464.25 γ)(497.36 γ +351.99 γ +212.67 γ)(θ): $A_2=-0.037$ 17, $A_4=+0.040$ 30 (2019Ur01), consistent with 6 \rightarrow 6 \rightarrow 4 and 7 \rightarrow 6 \rightarrow 4 spin sequences, with δ solution for 8 \rightarrow 6 \rightarrow 4 from the measurement using ^{248}Cm SF decay. |
| 1547.9 ‡ 2 | 0.2 ‡ 1 | 2609.66 | (6 ⁺) | 1061.96 | 6 ⁺ | | | |
| 1566.05 † 15 | 0.7 † 2 | 2130.62 | 5 ⁽⁺⁾ | 564.65 | 4 ⁺ | | | (1566.05 γ)(351.99 γ +212.67 γ)(θ): $A_2=-0.076$ 59, $A_4=+0.005$ 87 (2019Ur01), consistent with 4 \rightarrow 4 \rightarrow 2 and 5 \rightarrow 4 \rightarrow 2 spin sequences, with no δ solution for 6 \rightarrow 4 \rightarrow 2. δ : +1.0 4 for J(2131 level)=4 and +0.01 9 or +25 18 for J(2131 level)=5 from $\gamma\gamma(\theta)$ (2019Ur01), no δ solution for J(2131 level)=6. |
| 1643.5 ‡ 3 | 0.4 ‡ 2 | 1856.21 | 4 ⁺ | 212.67 | 2 ⁺ | | | |
| 1643.8 ‡ 1 | 1.1 ‡ 2 | 2208.49 | (5 ⁺) | 564.65 | 4 ⁺ | D+Q | | (1643.8 γ)(351.99 γ)(θ): $A_2=+0.077$ 49, $A_4=+0.003$ 69 (2019Ur02) consistent with 4 \rightarrow 4 \rightarrow 2, 5 \rightarrow 4 \rightarrow 2, and possibly also with 6 \rightarrow 4 \rightarrow 2 spin sequences. δ : +0.24 9 or +3 1 for J(2208 level)=5; +0.32 13 for J(2208 level)=4 (2019Ur02). |
| 1680.0 ‡ 1 | 0.7 ‡ 2 | 2244.71 | 4 ⁺ | 564.65 | 4 ⁺ | (M1+E2) | -1.7 3 | (1680.0 γ)(351.99 γ +212.67 γ)(θ): $A_2=+0.064$ 32, $A_4=+0.094$ 46 from ^{252}Cf SF decay; and $A_2=+0.111$ 35, $A_4=+0.107$ 56 from ^{248}Cm SF decay (2019Ur02), both consistent with 4 \rightarrow 4 \rightarrow 2 spin sequence. δ : for J(2245 level)=4, weighted average of $\delta(\text{Q/D})=-1.6$ 3 from ^{248}Cm SF decay and -2.0 4 from ^{252}Cf SF decay, with no δ solution obtained for J(2245 level)=5 or 6 (2019Ur02) in both the studies. |
| 1714.3 ‡ 1 | 2.5 ‡ 3 | 2776.18 | (7 ⁺) | 1061.96 | 6 ⁺ | | | |
| 1907.5 ‡ 2 | 0.2 ‡ 1 | 2471.89 | (6 ⁺) | 564.65 | 4 ⁺ | | | |

 † From 2019Ur01. ‡ From 2019Ur02.

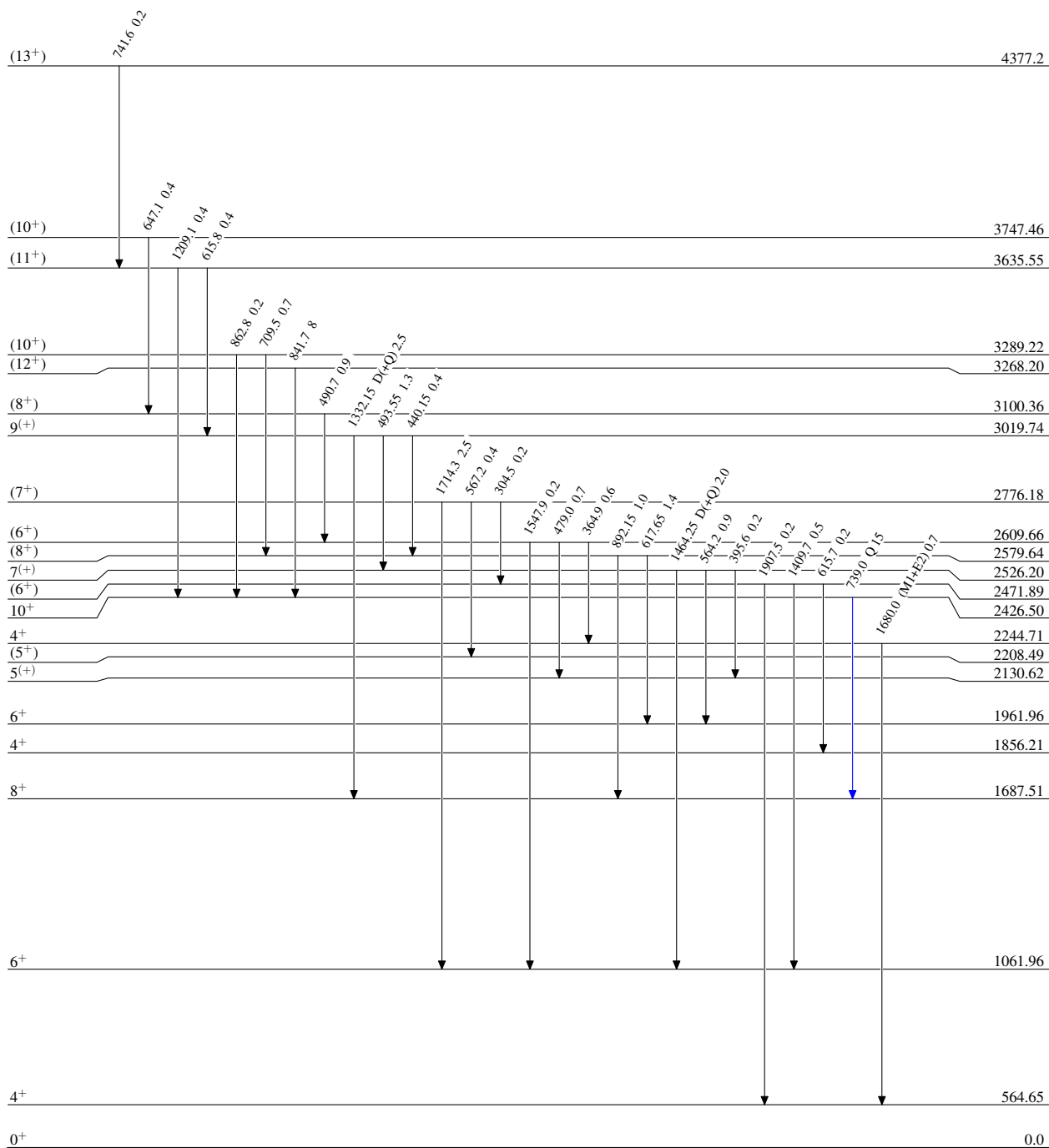
$^{248}\text{Cm}, ^{252}\text{Cf}$ SF decay 2019Ur01,2019Ur02

Level Scheme

Intensities: Type not specified

Legend

- $I_\gamma < 2\% \times I_\gamma^{\max}$
- $I_\gamma < 10\% \times I_\gamma^{\max}$
- $I_\gamma > 10\% \times I_\gamma^{\max}$



$^{100}_{40}\text{Zr}_{60}$

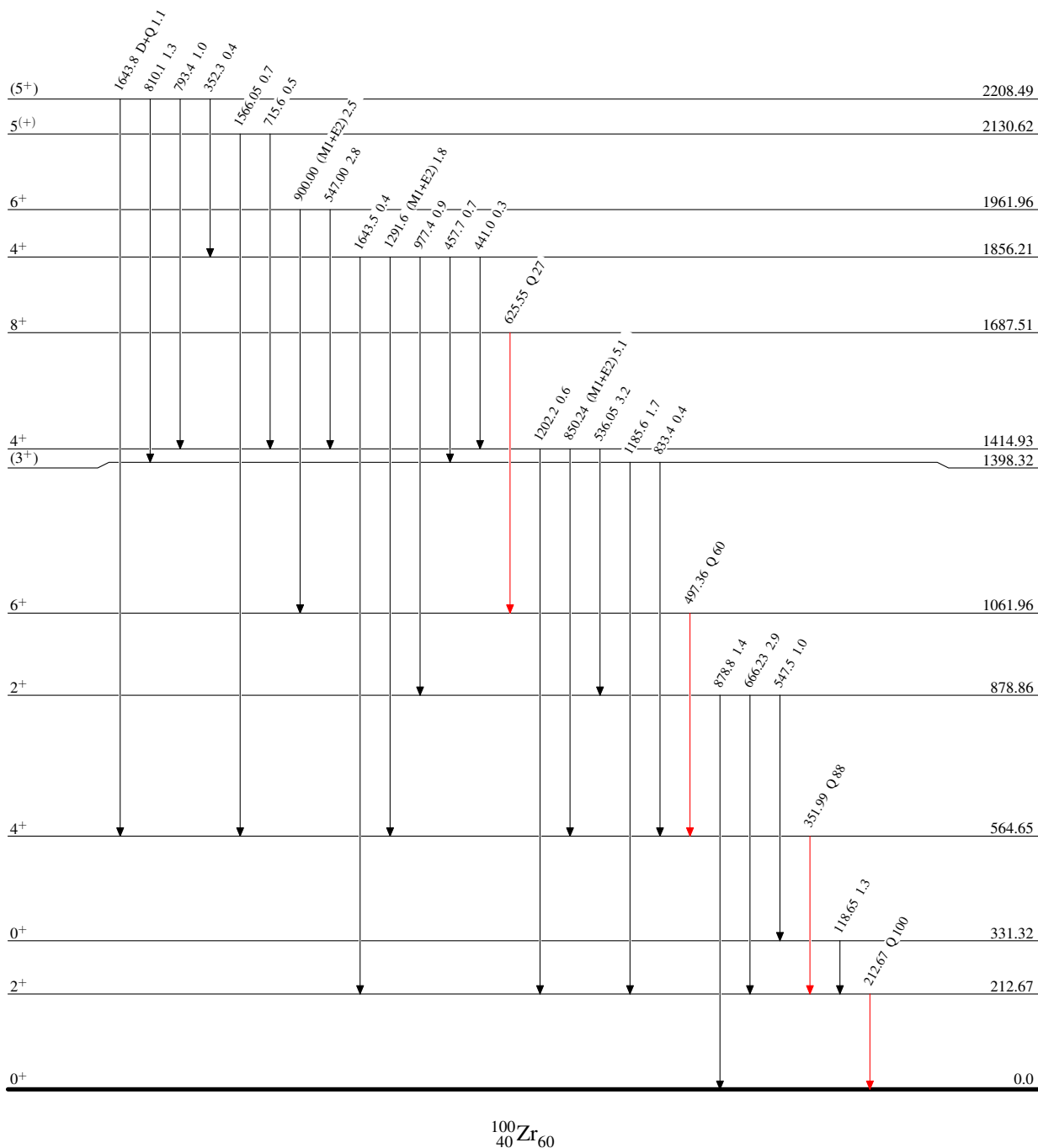
$^{248}\text{Cm}, ^{252}\text{Cf}$ SF decay 2019Ur01,2019Ur02

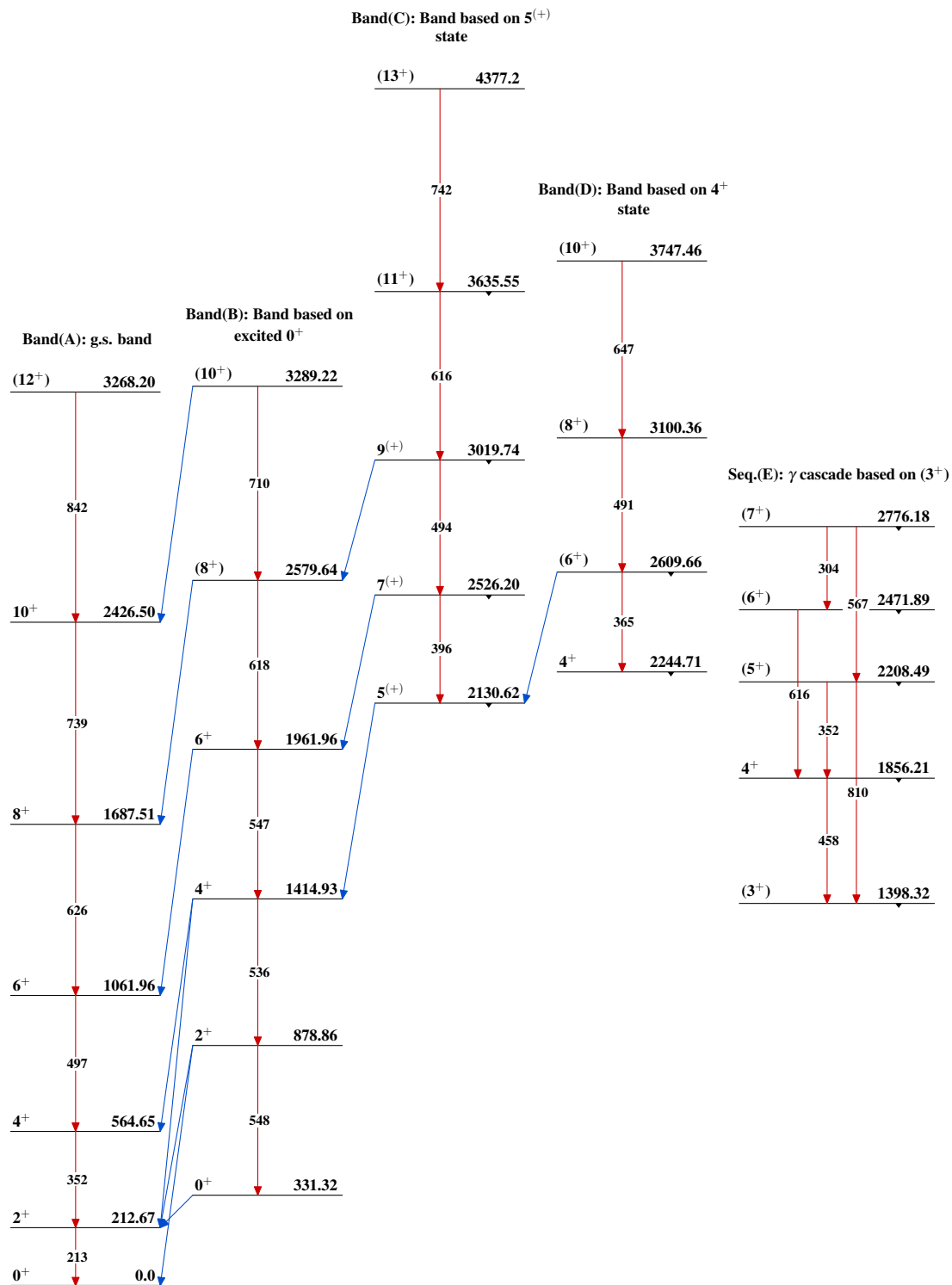
Level Scheme (continued)

Intensities: Type not specified

Legend

- $I_\gamma < 2\% \times I_\gamma^{\max}$
- $I_\gamma < 10\% \times I_\gamma^{\max}$
- $I_\gamma > 10\% \times I_\gamma^{\max}$



$^{248}\text{Cm}, ^{252}\text{Cf}$ SF decay 2019Ur01,2019Ur02 $^{100}_{40}\text{Zr}_{60}$