## Adopted Levels, Gammas

| Type | Author | History Citation | Literature Cutoff Date |
|---|---|---|---|
| Full Evaluation | Balraj Singh | ENSDF | 30-Sep-2020 |

Q($\beta^-$)=7203 *3*; S(n)=4557.5 *25*; S(p)=15102 *7*; Q($\alpha$)=−11106 *3* 2017Wa10
S(2n)=12372.9 *28*, S(2p)=29340 *300* (syst) (2017Wa10).
Measured mass excess for $^{77}$Ga=−65995.0 keV *42* (2019Hu15), as compared to −65992.3 keV *24* in 2017Wa10 leads to Q($\beta^-$)=7205.8 keV *47*.
1970OsZZ, 1977Al17: $^{77}$Zn isotope identified and produced in $^{235}$U(n,F) at OSIRIS facility, and subsequent counting of $\beta$ and $\gamma$ spectra.
2017Wr01: E(p)=1.4 GeV incident on $UC_x$ target at ISOLDE-CERN facility. The $^{77}$Zn nuclei were resonantly ionized using a resonant laser-ion source, accelerated to 30 keV, and separated by high-resolution separator. The ions were cooled using a gas-filled radio-frequency quadrupole (RFQ-ISCOOL). Measured hyperfine spectra using collinear laser spectroscopy using COLLAPS setup at ISOLDE-CERN. Deduced spins, $\mu$, Q, isomer. Comparison with large-scale shell model calculations. For the calibration of nuclear moments, $\mu$=+0.875479 *9* from literature and Q=+0.122 *10* (2017Wr01) for the stable $^{67}$Zn nuclide were used as references. See also 2017Ne04 review article.
2019Xi07: measured isotope shifts and charge radii using laser spectroscopy at ISOLDE-CERN.
Mass measurement: 2008Ba54: Penning trap mass spectrometer ISOLTRAP.
Additional neutron-decaying levels above S(n) are expected to be populated with allowed beta transitions from $^{77}$Cu decay (2009Pa35).
Theoretical calculations: consult the NSR database at www.nndc.bnl.gov for 10 primary theory references dealing with nuclear structure calculations, and radioactive decays.

### $^{77}$Zn Levels

Cross Reference (XREF) Flags

- A $^{77}$Cu $\beta^-$ decay (469.8 ms)
- B $^{77}$Zn IT decay (1.05 s)
- C $^{78}$Cu $\beta^-$n decay (331.7 ms)

| E(level) | J$^\pi$ | $T_{1/2}$ | XREF | Comments |
|---|---|---|---|---|
| 0.0 | 7/2$^+$ | 2.08 s *5* | ABC | %$\beta^-$=100<br>$\mu$=−0.9067 *1* (2017Wr01,2019StZV)<br>Q=+0.48 *4* (2017Wr01)<br>Measured $\delta$<r$^2$>($^{68}$Zn,$^{77}$Zn)=+0.440 fm$^2$ *5*(stat) *64*(syst) (2019Xi07, laser spectroscopy at ISOLDE-CERN).<br>Measured isotope shift $\delta\nu$($^{68}$Zn,$^{77}$Zn)=236.0 MHz *16*(stat) *120*(syst) (2019Xi07, laser spectroscopy at ISOLDE-CERN).<br>$T_{1/2}$: from 1986Ek01. Others: 2.20 s *18* (1981Ru07), 1.4 s *3* (1970OsZZ).<br>J$^\pi$: three quasi particles (neutrons) arising from $g_{9/2}$ orbital coupled to 7/2$^+$ assumed from shell model and systematics. The g.s. feeds a suggested $J^\pi$=9/2$^+$ state in $^{77}$Ga (2009Pa35,2009Il01).<br>$\mu$,Q: from measurement of hyperfine structure by collinear laser spectroscopy at ISOLDE-CERN (2017Wr01); measured $\mu$=−0.9074 *1* is re-evaluated to $\mu$=−0.9067 *1* by 2019StZV.<br>J$^\pi$: 7/2 from measurement of hyperfine structure by collinear laser spectroscopy at ISOLDE-CERN. Parity from agreement of measured $\mu$ with theoretical values (2017Wr01). |
| 114.721 *10* | (9/2$^+$) | | A C | XREF: C(?).<br>J$^\pi$: from systematics and shell-model predictions (2009Il01,2009Pa35). |
| 772.440 *15* | 1/2$^-$ | 1.05 s *10* | AB | %$\beta^-$=66 *7* (2009Il01); %IT=34 *7* (2009Il01)<br>$\mu$=+0.562 *2* (2017Wr01,2019StZV) |

Continued on next page (footnotes at end of table)

**Adopted Levels, Gammas (continued)**

$^{77}$Zn Levels (continued)

| E(level) | $J^\pi$ | XREF | Comments |
|---|---|---|---|
| | | | Others: %$\beta^-$>52 (2009Pa35), %IT>50 (1986Ek01).<br>Measured $\delta$<r$^2$>($^{68}$Zn,$^{77}$Zn)=+0.455 fm$^2$ *11*(stat) *64*(syst) (2019Xi07, laser spectroscopy at ISOLDE-CERN).<br>Measured isotope shift $\delta\nu$($^{68}$Zn,$^{77}$Zn)=241.2 MHz *38*(stat) *120*(syst) (2019Xi07, laser spectroscopy at ISOLDE-CERN).<br>$J^\pi$: 1/2 from measurement of hyperfine structure by collinear laser spectroscopy at ISOLDE-CERN. Parity from agreement of measured $\mu$ with theoretical values (2017Wr01). Probable $\nu p_{1/2}$ orbital (2009Pa35,2009Il01).<br>$T_{1/2}$: from 772.43$\gamma$(t) (1986Ek01).<br>$\mu$: from measurement of hyperfine structure by collinear laser spectroscopy at ISOLDE-CERN (2017Wr01). |
| 801.89 *11* | (11/2$^+$) | A C | XREF: C(?).<br>$J^\pi$: from systematics and shell-model predictions (2009Pa35). |
| 1130.5 *3* | | A | |
| 1235.1 *5* | | A | |
| 1277.690 *15* | (5/2$^-$,3/2$^+$) | A | $J^\pi$: 5/2$^-$ proposed by 2009Pa35, 3/2$^+$ by 2009Il01 and 2009Wi03, based on syst and shell-model predictions. |
| 1284.62 *15* | | A | |
| 1363.786 *25* | (1/2$^+$,3/2$^-$) | A | $J^\pi$: 3/2$^-$ proposed by 2009Pa35, 1/2$^+$ by 2009Il01, based on syst and shell-model predictions. |
| 1409.078 *20* | | A | |
| 1427.3 *3* | | A | |
| 1637.48 *21* | | A | |
| 1875.66 *11* | | A | |
| 2082.81 *4* | | A | |
| 2152.6 *23* | | A | |
| 2235.378 *24* | (5/2$^+$) | A | |
| 2380.4 *3* | | A | |
| 2527.2? *5* | | A | |
| 2545.84 *12* | | A | |
| 2574.2? *4* | | A | |
| 2654.14 *9* | | A | |
| 2872.67 *5* | | A | |
| 2891.8? *3* | | A | |
| 3001.12 *10* | | A | |
| 3083.18 *9* | | A | |
| 3095.1? *5* | | A | |
| 3139.30 *15* | | A | |
| 3204.56 *5* | | A | |
| 3386.92 *13* | | A | |
| 3426.98 *13* | | A | |
| 3709.9 *15* | | A | |
| 3744.00 *9* | | A | |
| 3823.88 *16* | | A | |
| 4334.35 *20* | | A | |
| 4531.9 *4* | | A | |
| 4605.27 *21* | | A | |

## $\gamma(^{77}$Zn)

| $E_i$(level) | $J^{\pi}_i$ | $E_{\gamma}$ | $I_{\gamma}$ | $E_f$ | $J^{\pi}_f$ | Mult. | $\delta$ | $\alpha$† | Comments |
|---|---|---|---|---|---|---|---|---|---|
| 114.721 | (9/2+) | 114.72 1 | 100 | 0.0 | 7/2+ | [M1+E2] | 0.10 3 | 0.046 2 | $\delta$: assumed in 2009Il01 with an uncertainty of 0.03, from similar 9/2+ to 7/2+ transitions amongst low-lying levels in $^{73}$Ge and $^{75}$Ge. |
| 772.440 | 1/2− | 772.43 2 | 100 | 0.0 | 7/2+ | [E3] | | 0.00133 | B(E3)(W.u.)=6.8×10$^{-6}$ 16<br>Mult.: the multipolarity may be E3, as suggested by the assigned $J^{\pi}$ values. Deduced B(E3)(W.u.) is smaller than any other value for A<90 (1979En04). In the A=80 region, B(E3)(W.u.) for 7/2+ to 1/2− range from 0.0362 6 for $^{77}$Se to 0.00071 4 for $^{81}$Se. |
| 801.89 | (11/2+) | 687.17 11 | 100 | 114.721 | (9/2+) | | | | $E_{\gamma}$: it is assumed that 685.5$\gamma$ in 2009Pa35 is the same as 688.7$\gamma$ in $^{78}$Cu $\beta^-$n decay data of 2005Va19 and 687.17 in $^{77}$Cu $\beta^-$ of 2009Il01. |
| 1130.5 | | 1015.8 3 | 100 | 114.721 | (9/2+) | | | | |
| 1235.1 | | 1120.4 5 | 100 | 114.721 | (9/2+) | | | | |
| 1277.690 | (5/2−,3/2+) | 505.25 1 | 100.0 7 | 772.440 | 1/2− | | | | |
| | | 1277.68 2 | 37.3 8 | 0.0 | 7/2+ | | | | |
| 1284.62 | | 1169.81 16 | 32 4 | 114.721 | (9/2+) | | | | |
| | | 1284.8 5 | 100 6 | 0.0 | 7/2+ | | | | |
| 1363.786 | (1/2+,3/2−) | 591.33 2 | 100 | 772.440 | 1/2− | | | | |
| 1409.078 | | 131.35 22 | 4.0 7 | 1277.690 | (5/2−,3/2+) | | | | |
| | | 1409.07 2 | 100 3 | 0.0 | 7/2+ | | | | |
| 1427.3 | | 1427.7 6 | 100 | 0.0 | 7/2+ | | | | |
| 1637.48 | | 352.86 15 | 100 | 1284.62 | | | | | |
| 1875.66 | | 466.88 25 | 55 15 | 1409.078 | | | | | |
| | | 1875.86 17 | 100 13 | 0.0 | 7/2+ | | | | |
| 2082.81 | | 805.11 3 | 100 | 1277.690 | (5/2−,3/2+) | | | | |
| 2152.6 | | 2037.9 23 | 100 | 114.721 | (9/2+) | | | | |
| 2235.378 | (5/2+) | 826.33 18 | 4.7 8 | 1409.078 | | | | | |
| | | 871.45 9 | 17.4 17 | 1363.786 | (1/2+,3/2−) | | | | |
| | | 957.69 2 | 100.0 22 | 1277.690 | (5/2−,3/2+) | | | | |
| | | 2118.8 4 | 5.5 14 | 114.721 | (9/2+) | | | | $E_{\gamma}$: poor fit, not included in the least-squares fitting procedure. Level-energy difference=2120.6. |
| | | 2234.3 4 | 3.6 11 | 0.0 | 7/2+ | | | | |
| 2380.4 | | 2265.6 3 | 100 | 114.721 | (9/2+) | | | | |
| 2527.2? | | 2527.2 5 | 100 | 0.0 | 7/2+ | | | | |
| 2545.84 | | 1268.14 12 | 100 | 1277.690 | (5/2−,3/2+) | | | | |
| 2574.2? | | 2459.4‡ 4 | | 114.721 | (9/2+) | | | | |
| 2654.14 | | 1290.34 8 | 100 | 1363.786 | (1/2+,3/2−) | | | | |
| 2872.67 | | 637.29 5 | 100 8 | 2235.378 | (5/2+) | | | | |
| | | 997.29 15 | 41 6 | 1875.66 | | | | | |
| | | 1463.69 14 | 53 7 | 1409.078 | | | | | |
| | | 1594.8 1 | 97 10 | 1277.690 | (5/2−,3/2+) | | | | |





$^{77}_{30}$Zn$_{47}$-3

## $\gamma$($^{77}$Zn) (continued)

| $E_i$(level) | $J^\pi_i$ | $E_\gamma$ | $I_\gamma$ | $E_f$ | $J^\pi_f$ | Comments |
|---|---|---|---|---|---|---|
| 2872.67 | | 2757.9 5 | 18 6 | 114.721 | (9/2$^+$) | |
| 2891.8? | | 1528.0‡ 3 | | 1363.786 | (1/2$^+$,3/2$^-$) | |
| 3001.12 | | 1723.41 9 | 100 | 1277.690 | (5/2$^-$,3/2$^+$) | |
| 3083.18 | | 1000.33 14 | 47 7 | 2082.81 | | |
| | | 1805.5 1 | 100 8 | 1277.690 | (5/2$^-$,3/2$^+$) | |
| | | 2967.6 7 | 14 6 | 114.721 | (9/2$^+$) | |
| 3095.1? | | 1817.4‡ 5 | | 1277.690 | (5/2$^-$,3/2$^+$) | |
| 3139.30 | | 903.8 14 | 89 16 | 2235.378 | (5/2$^+$) | |
| | | 1056.6 3 | 54 11 | 2082.81 | | |
| | | 1730.18 18 | 100 16 | 1409.078 | | |
| | | 3139.1 6 | 59 16 | 0.0 | 7/2$^+$ | |
| 3204.56 | | 1840.15 21 | 21 3 | 1363.786 | (1/2$^+$,3/2$^-$) | |
| | | 1926.87 4 | 100 3 | 1277.690 | (5/2$^-$,3/2$^+$) | |
| 3386.92 | | 2023.04 14 | 100 10 | 1363.786 | (1/2$^+$,3/2$^-$) | |
| | | 2109.4 3 | 65 10 | 1277.690 | (5/2$^-$,3/2$^+$) | |
| | | 3387.2 6 | 25 6 | 0.0 | 7/2$^+$ | |
| 3426.98 | | 2017.8 4 | 28 8 | 1409.078 | | |
| | | 2141.7 5 | 23 8 | 1284.62 | | |
| | | 2149.32 14 | 100 11 | 1277.690 | (5/2$^-$,3/2$^+$) | |
| 3709.9 | | 2432.2 15 | 100 | 1277.690 | (5/2$^-$,3/2$^+$) | |
| 3744.00 | | 1661.16 9 | 100 14 | 2082.81 | | |
| | | 2335.1 3 | 18 6 | 1409.078 | | |
| | | 2466.6 7 | 12 4 | 1277.690 | (5/2$^-$,3/2$^+$) | E$\gamma$=2463.6 10, I$\gamma$=6 2 (2009Pa35), placed from 3826 level in 2009Pa35 on the basis of coin with 591$\gamma$. The evaluators assume that same $\gamma$ is seen in both 2009Il01 and 2009Pa35. 2463.6-591.1 $\gamma\gamma$ coin result of 2009Pa35 seems in disagreement with that from 2009Il01. |
| | | 3743.6 4 | 21 5 | 0.0 | 7/2$^+$ | |
| 3823.88 | | 2396.6 3 | 47 7 | 1427.3 | | |
| | | 2546.12 16 | 100 8 | 1277.690 | (5/2$^-$,3/2$^+$) | |
| | | 3826.7‡ 10 | 39 13 | 0.0 | 7/2$^+$ | |
| 4334.35 | | 4220.5 16 | 9 5 | 114.721 | (9/2$^+$) | |
| | | 4334.2 2 | 100 11 | 0.0 | 7/2$^+$ | |
| 4531.9 | | 4417.0 4 | 100 | 114.721 | (9/2$^+$) | |
| 4605.27 | | 3178.0 6 | 41 9 | 1427.3 | | |
| | | 4490.37 23 | 100 13 | 114.721 | (9/2$^+$) | |
| | | 4605.3 6 | 30 7 | 0.0 | 7/2$^+$ | |

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

‡ Placement of transition in the level scheme is uncertain.





$^{77}_{30}Zn_{47}$-4

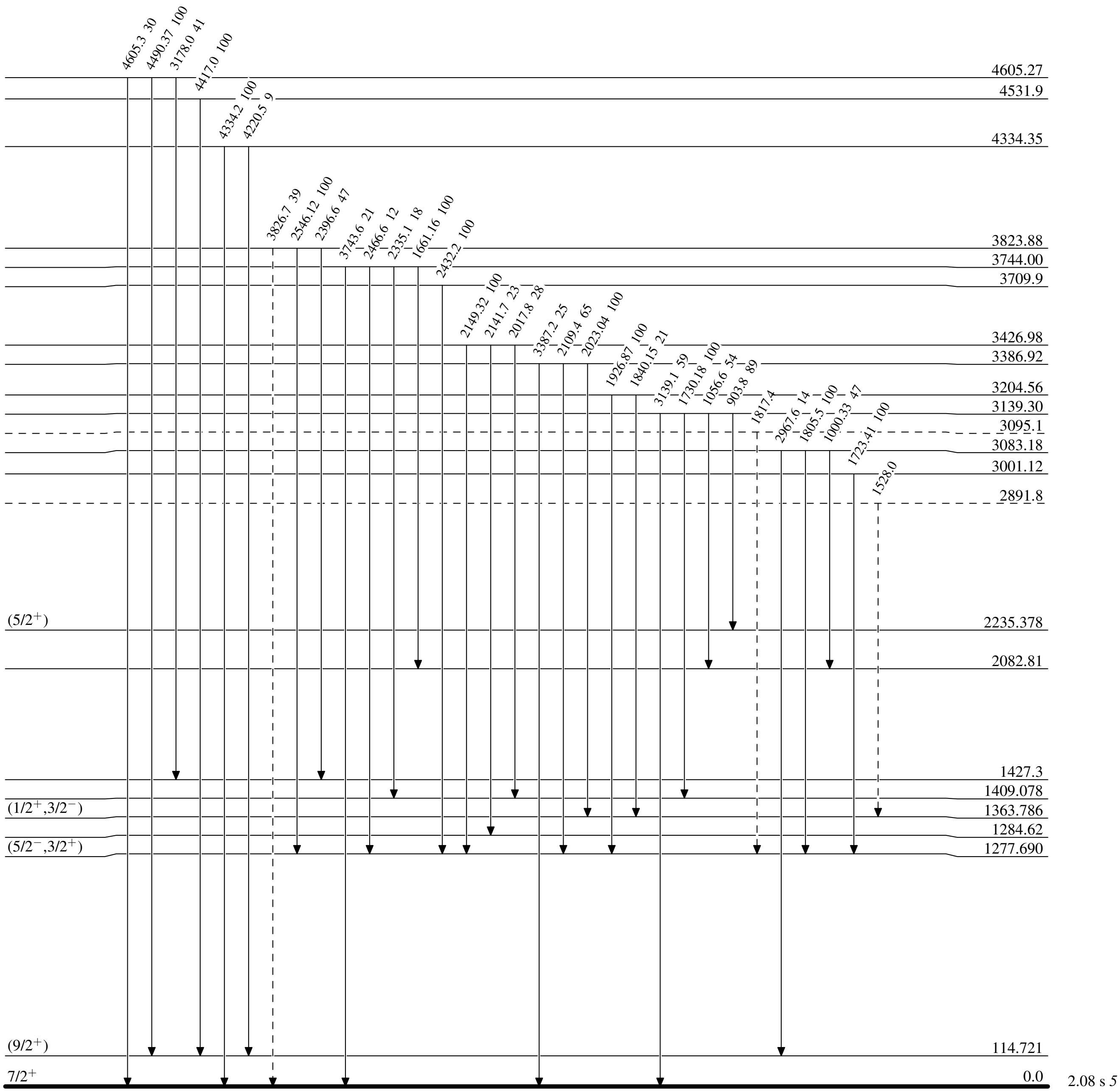
**Adopted Levels, Gammas**

Level Scheme

Intensities: Relative photon branching from each level

Legend

γ Decay (Uncertain)




$^{77}_{30}Zn_{47}$

**Adopted Levels, Gammas**

Level Scheme (continued)

Intensities: Relative photon branching from each level