

**${}^{62}\text{Ga}$   $\varepsilon$  decay (116.121 ms) 2008Fi07,2006Hy02,2008Be21**

| Type            | Author   | History | Citation            | Literature Cutoff Date |
|-----------------|--|---------|---------------------|------------------------|
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Parent:  ${}^{62}\text{Ga}$ :  $E=0.0$ ;  $J^\pi=0^+$ ;  $T_{1/2}=116.121$  ms 21;  $Q(\varepsilon)=9181.07$  38;  $\% \varepsilon + \% \beta^+$  decay=100.0

${}^{62}\text{Ga}$ - $T_{1/2}$ : From Adopted Levels.

${}^{62}\text{Ga}$ - $Q(\varepsilon)$ : From 2011AuZZ, based on  $Q(\varepsilon)=9181.07$  54 from Penning-trap mass measurement (2006Er03). 2003Au03 list 9171 26.

2008Fi07:  ${}^{62}\text{Ga}$  produced in the  $\text{Zr}(p,X)$  reaction using 500 MeV protons produced at the ISAC facility at TRIUMF. Detected  $\beta^+$  particles with SCEPTAR array of 20 plastic scintillators. Measured  $E_\gamma$ ,  $I_\gamma$ ,  $\gamma\gamma$ ,  $\beta\gamma$  coin using  $8\pi$  array of 20 HPGe detectors with Compton-suppression and SCEPTAR array of plastic scintillators for  $\beta$  particles. Deduced precise and accurate  $\beta^+ + \varepsilon$  branch to g.s. of  ${}^{62}\text{Zn}$  and associated log  $ft$  value relevant to superallowed  $\beta$  decay from  $0^+$  to  $0^+$  state and breaking of isospin symmetry.

2008Be21, 2005Ca06:  ${}^{62}\text{Ga}$  was produced in bombardment of  ${}^{64}\text{Zn}$  target by 48 MeV protons at IGISOL facility in Jyvaskyla.

Fusion evaporation residues were thermalized in helium gas and singly-charged ions were mass analyzed. JYFLTRAP facility was used to separate  ${}^{62}\text{Ga}$  from other isobaric activities. Penning-trap separated  ${}^{62}\text{Ga}$  was used for measurement of  $E_\gamma$  and  $I_\gamma$ .

Different measurement cycles were used on the mass-separated source in another setup. Detection system consisted of three HPGe clover detectors (for  $\gamma$  rays), and  $4\pi$  cylindrical plastic scintillators for  $\beta$  particles. Measured  $E_\gamma$ ,  $I_\gamma$ ,  $\gamma\gamma$  and  $\beta\gamma$  coin. Half-life measurement in 2005Ca06.

2008Gr03:  $E=500$  MeV protons produced at TRIUMF cyclotron.  ${}^{62}\text{Ga}$  beam produced using TRILIS. Measured  $\beta$  particles using  $4\pi$  gas counter and 20 plastic scintillators. Detected  $\gamma$  rays with  $8\pi$   $\gamma$ -ray spectrometer. Measured precise half-life of  ${}^{62}\text{Ga}$  decay.

2006Hy02 (also 2005Hy04):  ${}^{62}\text{Ga}$  was produced in spallation reaction by 500 MeV protons on a ZrC target. Mass-separated 30-keV  ${}^{62}\text{Ga}$  beam was obtained using a laser ion source at TRIUMF-ISAC facility and implanted in a Mylar tape for  $\gamma$  and  $\beta$  counting. Measured  $E_\gamma$ ,  $I_\gamma$ ,  $\gamma\gamma$ ,  $\beta$ ,  $\beta\gamma$  coin using  $8\pi$  array of 20 Compton-suppressed HPGe detectors for  $\gamma$  rays and an array of 20 plastic scintillators for  $\beta$  rays. Half-life measurement is reported by 2005Hy04. Same group as 2008Fi07 and 2008Gr03.

2004B103:  ${}^{62}\text{Ga}$  from  ${}^{28}\text{Si}({}^{40}\text{Ca},n\text{p}\alpha)$  at GSI; measured half-life,  $\beta\gamma$  coin.

2003Hy02:  ${}^{62}\text{Ga}$  from  ${}^1\text{H}({}^{64}\text{Zn},3n)$  at 42 MeV/nucleon; measured  $E_\gamma$ ,  $I_\gamma$ , half-life, branching ratios.

2002Lo13 (also 2002B117):  ${}^{62}\text{Ga}$  from fragmentation of  ${}^{78}\text{Kr}$  beam, GANIL facility, measured half-life.

1993Wi18, 1993Wi03:  ${}^{58}\text{Ni}({}^{84}\text{Kr},X)$   $E=75$  MeV/nucleon. Measured half-life.

1979Da04: from  ${}^{58}\text{Ni}({}^6\text{Li},2n)$ ,  $E=25$  MeV,  $\Delta E$ - $E$  telescopes (plastic or semiconductors),  $T_{1/2}$ ,  $Q(\varepsilon)$ .

1978A123: from  ${}^{58}\text{Ni}({}^6\text{Li},2n)$ ,  $E=25$  MeV, plastic scintillator, half-life.

1978Ch11: from  ${}^{64}\text{Zn}(p,3n)$ ,  $E=44$  MeV, plastic scintillator, half-life,  $Q(\beta^+)$ .

1976BaXP: from  $\text{Zn}(p,3n)$ ,  $E=44$  MeV, half-life.

1976JaZP: from  ${}^{46}\text{Ti}({}^{19}\text{F},3n)$  and  ${}^{50}\text{Cr}({}^{16}\text{O},p3n)$ , plastic scintillator, half-life.

1973ChYF: from  ${}^{64}\text{Zn}(p,3n)$ ,  $E=32$ - $52$  MeV, plastic scintillator, Ge(Li).

2008Fi07, 2008Gr03, 2006Hy02 (also 2005Hy04) are from the same group.

2008Be21, 2005Ca06, 2004B103, 2002Lo13 (also 2002B117) share some of the same authors, but some of the studies are at different facilities.

Review of superallowed ( $0^+$  to  $0^+$ )  $\beta$  decays: 2010To12, 2009Er02, 2009Ha12, 2008To03, 2005Ha27, 2002Ha27; also 2006Ha12, 2005Ha15, 2005Ha65 conference papers.

#### Additional information 1.

Notes on half-life measurement of  ${}^{62}\text{Ga}$ :

2008Gr03:  ${}^{62}\text{Ga}$  beam from TRIUMF ISAC using resonant ionization laser ion source and mass separation, positron detection using  $4\pi$  continuous flow gas proportional counter. Yields and activities of  ${}^{62}\text{Cu}$ ,  ${}^{62\text{m}}\text{Co}$ ,  ${}^{62\text{g}}\text{Co}$ ,  ${}^{62}\text{Mn}$  and  ${}^{62}\text{Fe}$  contaminants were estimated from  $\beta\gamma$  coin. data. Systematic and statistical uncertainties described in detail.

2005Ca06:  ${}^{62}\text{Ga}$  beam from IGISOL at Jyvaskyla. Positron detection using  $4\pi$  cylindrical plastic scintillator. Presence of  ${}^{62}\text{Cu}$  activity was considered as a constant background. Systematic and statistical uncertainties described in detail.

2004B103:  ${}^{62}\text{Ga}$  beam from  ${}^{28}\text{Si}({}^{40}\text{Ca},\text{npn})$  at 4.84 MeV/nucleon at GSI facility. Mass-analyzed beam and positron detection using  $4\pi$  gas detector and  $\gamma$  by HPGe detector.  ${}^{62}\text{Cu}$  and  ${}^{62}\text{Zn}$  impurities were taken into account. Systematic and statistical uncertainties described in detail.

2003Hy02:  ${}^{62}\text{Ga}$  beam from  ${}^1\text{H}({}^{64}\text{Zn},3n)$  at 42 MeV/nucleon at Texas A&M facility. Mass-analyzed beam was 80-94% pure  ${}^{62}\text{Ga}$ . Positron detection using  $4\pi$  gas proportional chamber.  ${}^{58}\text{Cu}$  and  ${}^{54}\text{Co}$  impurities quantified. The  $\gamma$  spectrum was measured by HPGe detector. Maximum likelihood method. Uncertainty analysis not discussed fully.

2002Lo13 (also 2002B117):  ${}^{62}\text{Ga}$  from fragmentation of  ${}^{78}\text{Kr}$  beam, GANIL facility, decay curve of  $\beta^+$  particles correlated with implants shown; no discussion of uncertainties.

**$^{62}\text{Ga}$   $\varepsilon$  decay (116.121 ms) 2008Fi07,2006Hy02,2008Be21 (continued)**

Total decay energy of 9181.2 keV 7 deduced (by RADLIST code) from proposed decay scheme is in agreement with the expected value of 9181.1 keV 4, indicating that decay scheme is complete.

$^{62}\text{Zn}$  Levels

| E(level) <sup>†</sup> | J <sup>π</sup> <sup>‡</sup> | T <sub>1/2</sub> | Comments                                |
|-----------------------|-----------------------------|------------------|---|
| 0.0                   | 0 <sup>+</sup>              | 9.193 h 15       | T <sub>1/2</sub> : from Adopted Levels. |
| 953.87 17             | 2 <sup>+</sup>              |                  |   |
| 1804.78 21            | 2 <sup>+</sup>              |                  |   |
| 2342.2 3              | 0 <sup>+</sup>              |                  |   |
| 2803.5 3              | 2 <sup>+</sup>              |                  |   |
| 3042.9? 9             | (0 <sup>+</sup> )           |                  |   |
| 3181.2 4              | (1 <sup>+</sup> )           |                  |   |
| 3374.3 4              | (1 <sup>-</sup> )           |                  |   |
| 3960.8 4              | (1 <sup>+</sup> )           |                  |   |
| 4021.7 5              | (1 <sup>+</sup> )           |                  |   |
| 4448.2 3              | (1 <sup>+</sup> )           |                  |   |
| 4895.6 5              | (1 <sup>+</sup> )           |                  |   |
| 5211.6 5              | (1 <sup>+</sup> )           |                  |   |
| 5920.8? 17            | (1 <sup>+</sup> )           |                  |   |

<sup>†</sup> From least-squares fit to E<sub>γ</sub> data.

<sup>‡</sup> From Adopted Levels.

$\varepsilon, \beta^+$  radiations

| E(decay)                 | E(level) | I <sub>β<sup>+</sup></sub> <sup>#</sup> | I <sub>ε</sub> <sup>#</sup> | Log ft <sup>†</sup> | I(ε+β <sup>+</sup> ) <sup>#</sup> | Comments  |
|--------------------------|----------|---|-----------------------------|---------------------|-----------------------------------|---|
| (3260.3 <sup>@</sup> 18) | 5920.8?  | 0.0008 4                                | 5.×10 <sup>-5</sup> 2       | 6.03 22             | 0.0008 4                          | av Eβ=993.20 84; εK=0.05110 12;<br>εL=0.005639 13; εM+=0.0010032 2  |
| (3969.5 6)               | 5211.6   | 0.0107 10                               | 0.00028 3                   | 5.41 4              | 0.0110 10                         | av Eβ=1326.80 35; εK=0.02293 2;<br>εL=0.002528 2; εM+=0.0004497 4   |
| (4285.5 6)               | 4895.6   | 0.0096 9                                | 0.00019 2                   | 5.66 4              | 0.0098 9                          | av Eβ=1477.09 36; εK=0.01700 2;<br>εL=0.001874 2; εM+=0.0003333 3   |
| (4732.9 5)               | 4448.2   | 0.0271 14                               | 0.000362 19                 | 5.46 2              | 0.0275 14                         | av Eβ=1691.20 30; εK=0.011648 6;<br>εL=0.0012831 7; εM+=0.0002282 2   |
| (5159.4 6)               | 4021.7   | 0.0171 12                               | 0.000165 12                 | 5.88 3              | 0.0173 12                         | av Eβ=1896.50 36; εK=0.008452 5;<br>εL=0.0009308 5; εM+=0.000166  |
| (5220.3 6)               | 3960.8   | 0.0054 7                                | 4.9×10 <sup>-5</sup> 6      | 6.41 6              | 0.0054 7                          | av Eβ=1925.90 33; εK=0.008096 4;<br>εL=0.0008916 5; εM+=0.000159  |
| (5806.8 6)               | 3374.3   | 0.0054 9                                | 3.4×10 <sup>-5</sup> 6      | 6.67 8              | 0.0054 9                          | av Eβ=2209.93 33; εK=0.005505 3;<br>εL=0.0006061 3; εM+=0.000108<br>I(ε+β <sup>+</sup> ): if J <sup>π</sup> (3374 level)=2 <sup>+</sup> , the listed β<br>feeding must result from unobserved γ<br>rays depopulating higher levels. |
| (5999.9 6)               | 3181.2   | 0.0302 12                               | 0.000168 7                  | 6.00 2              | 0.0304 12                         | av Eβ=2303.76 33; εK=0.004899 2;<br>εL=0.0005393 3; εM+=9.591×10 <sup>-5</sup> 4  |
| (6138.2 <sup>@</sup> 10) | 3042.9?  | 0.0012 5                                | 6.×10 <sup>-6</sup> 3       | 7.46 18             | 0.0012 5                          | av Eβ=2371.06 52; εK=0.004518 3;<br>εL=0.0004973 3; εM+=8.846×10 <sup>-5</sup> 6  |
| (6838.9 5)               | 2342.2   | 0.0064 14                               | 2.2×10 <sup>-5</sup> 5      | 6.99 10             | 0.0064 14                         | av Eβ=2712.98 31; εK=0.003094 1;<br>εL=0.0003405 1; εM+=6.055×10 <sup>-5</sup> 2  |
| (7376.3 <sup>@</sup> 4)  | 1804.78  |   |                             |                     | 0.0105 <sup>‡</sup> 13            |   |
| (8227.2 <sup>@</sup> 4)  | 953.87   |   |                             |                     | 0.012 <sup>‡</sup> 3              |   |
| (9181.1 4)               | 0.0      | 99.729 8                                | 0.1285 13                   | 3.48819 16          | 99.858 8                          | av Eβ=3864.42; εK=0.0011394 3;<br>εL=0.0001253; εM+=2.2283×10 <sup>-5</sup> 5   |

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**$^{62}\text{Ga}$   $\epsilon$  decay (116.121 ms) 2008Fi07,2006Hy02,2008Be21 (continued)**

$\epsilon, \beta^+$  radiations (continued)

| <u>E(decay)</u> | <u>E(level)</u> | <u>Comments</u>  |
|-----------------|-----------------|--|
|                 |                 | $I(\epsilon + \beta^+)$ : 100-( $\beta$ feeding to excited states deduced from measured values and missing intensity estimated from shell model calculations, 2008Fi07). Others: 99.893 24 (2008Be21, from measured $I_\gamma(\text{to g.s.})=0.086$ 9, and theoretically predicted unobserved $I_\gamma(\text{to g.s.})=0.025$ 7 from higher $1^+, 0^+$ states), 99.861 11 (2006Hy02, previous value from the same group as 2008Fi07), 99.8 1 (2005Ca06), 99.85 +5-15 (2003Hy02), 99.88 3 (2002B117). Superallowed $0^+$ to $0^+$ $\beta$ transition. Using the averaged half-life, 2008Fi07 deduced $ft=3074.3$ 11 (log $ft=3.4877$ 2) for superallowed $0^+$ to $0^+$ $\beta$ transition. |
|                 |                 | E(decay): 9171 26 (1979Da04, from measured $\beta^+$ endpoint).  |

† Deduced from ‘LOGFT’ code available at [www.nndc.bnl.gov](http://www.nndc.bnl.gov).

‡ Apparent feedings due to unobserved  $\gamma$  transitions from higher ( $1^+$ ) levels, as also shown in the theoretical level scheme of Fig. 8 in 2008Fi07. For  $\Delta J=2$ ,  $\Delta\pi=\text{no}$ , log  $ft>11$ , and therefore almost no  $\beta$  feeding expected.

# Absolute intensity per 100 decays.

@ Existence of this branch is questionable.

$\gamma(^{62}\text{Zn})$

$I_\gamma$  normalization: Absolute  $\gamma$ -ray intensities/100 decays are measured by 2008Fi07.

| <u><math>E_\gamma</math></u> | <u><math>I_\gamma^\dagger</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> | <u>Comments</u>   |
|------------------------------|--------------------------------------|---------------------------------------|-----------------------------|-------------------------|-----------------------------|---|
| 850.9 2                      | 0.0100 7                             | 1804.78                               | $2^+$                       | 953.87                  | $2^+$                       | Additional information 3.   |
| 953.9 2                      | 0.0850 19                            | 953.87                                | $2^+$                       | 0.0                     | $0^+$                       | Additional information 2.<br>$I_\gamma$ : others: 0.086 9 (2008Be21), 0.0809 33 (2006Hy02), 0.11 4 (2005Ca06), 0.120 21 (2003Hy02), 0.12 3 (2002B117), 0.106 17 (Doring: ENAM-2001 conference proceedings, p323, 2000DoZX). |
| 1032.0 5                     | 0.0006 5                             | 3374.3                                | $(1^-)$                     | 2342.2                  | $0^+$                       |   |
| 1156.7 4                     | 0.0019 5                             | 3960.8                                | $(1^+)$                     | 2803.5                  | $2^+$                       |   |
| 1388.5 3                     | 0.0191 8                             | 2342.2                                | $0^+$                       | 953.87                  | $2^+$                       | Additional information 5.   |
| 1569.8 4                     | 0.0030 5                             | 3374.3                                | $(1^-)$                     | 1804.78                 | $2^+$                       |   |
| 1619.2 4                     | 0.0035 5                             | 3960.8                                | $(1^+)$                     | 2342.2                  | $0^+$                       |   |
| 1644.7 5                     | 0.0021 5                             | 4448.2                                | $(1^+)$                     | 2803.5                  | $2^+$                       | Additional information 11.  |
| 1679.3 6                     | 0.0008 5                             | 4021.7                                | $(1^+)$                     | 2342.2                  | $0^+$                       |   |
| 1805.0 4                     | 0.0070 6                             | 1804.78                               | $2^+$                       | 0.0                     | $0^+$                       | Additional information 4.   |
| 1849.6 4                     | 0.0072 6                             | 2803.5                                | $2^+$                       | 953.87                  | $2^+$                       | Additional information 6.   |
| 2089.0 <sup>‡</sup> 8        | 0.0012 5                             | 3042.9 <sup>‡</sup>                   | $(0^+)$                     | 953.87                  | $2^+$                       |   |
| 2092.5 4                     | 0.0047 6                             | 4895.6                                | $(1^+)$                     | 2803.5                  | $2^+$                       | Additional information 16.  |
| 2105.9 4                     | 0.0061 6                             | 4448.2                                | $(1^+)$                     | 2342.2                  | $0^+$                       | Additional information 12.  |
| 2227.2 4                     | 0.0262 11                            | 3181.2                                | $(1^+)$                     | 953.87                  | $2^+$                       | Additional information 7.   |
| 2408.3 7                     | 0.0013 4                             | 5211.6                                | $(1^+)$                     | 2803.5                  | $2^+$                       |   |
| 2643.9 6                     | 0.0026 5                             | 4448.2                                | $(1^+)$                     | 1804.78                 | $2^+$                       | Additional information 13.  |
| 2802.0 12                    | 0.0006 4                             | 2803.5                                | $2^+$                       | 0.0                     | $0^+$                       |   |
| 2869.8 7                     | 0.0017 4                             | 5211.6                                | $(1^+)$                     | 2342.2                  | $0^+$                       | Additional information 18.  |
| 3068.1 8                     | 0.0016 4                             | 4021.7                                | $(1^+)$                     | 953.87                  | $2^+$                       | Additional information 9.   |
| 3089.0 10                    | 0.0009 4                             | 4895.6                                | $(1^+)$                     | 1804.78                 | $2^+$                       |   |
| 3181.3 6                     | 0.0042 5                             | 3181.2                                | $(1^+)$                     | 0.0                     | $0^+$                       | Additional information 8.   |
| 3373.5 8                     | 0.0018 4                             | 3374.3                                | $(1^-)$                     | 0.0                     | $0^+$                       |   |
| 3493.9 7                     | 0.0058 6                             | 4448.2                                | $(1^+)$                     | 953.87                  | $2^+$                       | Additional information 14.  |
| 4021.7 8                     | 0.0149 10                            | 4021.7                                | $(1^+)$                     | 0.0                     | $0^+$                       | Additional information 10.  |
| 4256.6 9                     | 0.0029 4                             | 5211.6                                | $(1^+)$                     | 953.87                  | $2^+$                       | Additional information 19.  |
| 4447.8 9                     | 0.0109 8                             | 4448.2                                | $(1^+)$                     | 0.0                     | $0^+$                       | Additional information 15.  |
| 4894.4 10                    | 0.0042 5                             | 4895.6                                | $(1^+)$                     | 0.0                     | $0^+$                       | Additional information 17.  |

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${}^{62}\text{Ga}$   $\varepsilon$  decay (116.121 ms) 2008Fi07,2006Hy02,2008Be21 (continued) $\gamma({}^{62}\text{Zn})$  (continued)

| $E_\gamma$ | $I_\gamma^\dagger$ | $E_i(\text{level})$ | $J_i^\pi$         | $E_f$ | $J_f^\pi$      | Comments                   |
|------------|--------------------|---------------------|-------------------|-------|----------------|----------------------------|
| 5211.5 11  | 0.0051 6           | 5211.6              | (1 <sup>+</sup> ) | 0.0   | 0 <sup>+</sup> | Additional information 20. |
| 5920.5‡ 17 | 0.0008 4           | 5920.8?             | (1 <sup>+</sup> ) | 0.0   | 0 <sup>+</sup> |                            |

† Absolute intensity per 100 decays.

‡ Placement of transition in the level scheme is uncertain.

**$^{62}\text{Ga}$   $\epsilon$  decay (116.121 ms) 2008Fi07,2006Hy02,2008Be21**

Decay Scheme

Legend

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

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

