65Zn - Comments on evaluation of decay data
by R. G. Helmer

1 Decay scheme

This evaluation was originally completed in September 1996 with minor editing in January 1997 and post-review editing in January 1998. The literature available by June 1996 was included. The decay scheme is complete since the two excited levels in 65Cu below the decay energy are populated. Also, there is excellent agreement between the total decay energy of 1352 (4) keV computed for this decay scheme by RADLST and the Q value of 1351.9 (3) keV.

2 Nuclear Data

Q value is from Audi and Wapstra 1995 (95Au04).

The 65Zn half-life values available are, in days:

- 245.0 (8) 53To17
- 243.5 (8) 57Ge07
- 246.4 (22) 57Wr37
- 243.1 (7) 65An07
- 244.12 (12) " 
- 242.78 (19) " omitted from analysis
- 243 (4) 68Ha47
- 258 (4) 72Cr02 omitted from analysis
- 246 (5) " 
- 251 (6) " 
- 252 (6) " 
- 244.0 (2) 73Vi13
- 244.3 (4) 74Cr05
- 243.75 (12) 75La16 quoted uncertainty divided by 3
- 244.2 (1) 82HoZJ replaced by 92Un01
- 243.97 (8) 82DeYX replaced by 83Wa26
- 243.9 (3) 83Wa26
- 244.16 (10) 92Un01
- 244.06 (10) Adopted

The four values of 72Cr02 were omitted because they were not intended as T1/2 measurements, but rather to determine the origin of certain γ-rays.

The very small uncertainty, 0.02, given by 73Vi13 appears unrealistic when compared to the other quoted uncertainties. The question is how much to expand it and each analysis method will increase it by a different amount. For the remaining thirteen values the Limitation of Relative Statistical Weight (LRSW) method only increases the uncertainty of 73Vi13 from 0.02 to 0.056 to reduce its relative weight from 89% to 50%. Then, the weighted average is 244.22 with an internal uncertainty of 0.04, a reduced-$\chi^2 = 9.2$, and an external uncertainty of 0.12, but the method would expand the uncertainty to 0.30 to include the most precise value of 244.52. For this average, the 242.78 value of 65An07 contributed over 50% of the $\chi^2$ value.

The method of Normalized Residuals (92Ja06) with all 17 values increases the uncertainties for four more discrepant values, namely to 242.78 (61), 258 (5), 244.52 (21), and 243.75 (13) and then gives a weighted average of 244.06 (8). The RAJEVAL method (92Ra08) with all 17 values increases the uncertainties for five discrepant values, namely to 244.12 (18), 242.78 (84), 258 (7), 244.53 (25), and 243.75 (19) and then gives a weighted average of 244.09 (7).
With these results in mind, the evaluator has chosen to omit the value of 242.78 (19) as clearly discrepant along with the values from 72Cr02. Also, the uncertainty of the 73Vi13 value was increased from 0.02 to 0.20 as suggested by the Normalized Residual and RAJEVAL analyses. Then, the weighted average of the remaining twelve values is 244.06 with an internal uncertainty of 0.06, a reduced-$\chi^2$ of 1.72, and an external uncertainty of 0.07. The LRSW method gives the same value since no input value has more than 50% of the weight, but the uncertainty on the final value is increased to 0.10 to include the most precise value of 244.16 within its range; this value is adopted.

2.1 Electron Capture Transitions

The $\varepsilon$ branch to the 770-keV level is $2^{nd}$ forbidden. From the log $\beta$ systematics (73Ra10), the expected log $\beta$ value is > 11.0 and the corresponding $L_t(0)$ is < 0.003%.

The $P_K$ etc. values are computed from the Schönfeld tables (95ScZY). These values agree well with those from LOGFT program ($S =$ Schönfeld, $L =$ LOGFT):

<table>
<thead>
<tr>
<th>Level energy (keV)</th>
<th>$P_K$ (S)</th>
<th>$P_K$ (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1115</td>
<td>0.8853 (16)</td>
<td>0.8794 (17)</td>
</tr>
<tr>
<td></td>
<td>0.886</td>
<td>0.880</td>
</tr>
<tr>
<td>$P_L$ (S)</td>
<td>0.0977 (15)</td>
<td>0.1027 (16)</td>
</tr>
<tr>
<td></td>
<td>0.097</td>
<td>0.102</td>
</tr>
</tbody>
</table>

2.2 Gamma Transitions

The multipolarities are from the Adopted $\gamma$-ray data in the Nuclear Data Sheets (93Bh04). The internal-conversion coefficients are interpolated from the tables of Band (76Ba63), except for the 1115-keV $\gamma$-ray. For the 1115, the total and K-shell values, $1.85 \times 10^{-4}$ (7) and $1.66 \times 10^{-4}$ (6), are from the 85HaZA evaluation of the measured data. The Band values are in excellent agreement with these values; they are $\alpha = 0.000183$ and $\alpha_K = 0.000166$. The L-shell value is from Band.

From the theoretical tables of 79Sc31, the internal-pair-formation coefficients are $\alpha_p(1115, M1) = 1.2 \times 10^{-6}$ and $\alpha_p(1115, E2) = 1.6 \times 10^{-6}$, so $\alpha_p(1115) = 1.3 \times 10^{-6}$. This value is about 1% of the internal-conversion coefficient, so it is negligible.

3 Atomic Data (Cu, Z=29)

Data are from 96Sc06.

3.1 X Radiation

The data were computed with RADLST with the atomic data of Schönfeld (95ScZY).

3.2 Auger Electrons

The K Auger electron intensity from RADLST was divided into three components based on the data of Schönfeld and Janßen (96Sc06).

4.1 Electron Emission

The $\beta^+$ intensity to the ground state was computed from the measured $P_{\gamma}(1115)$, $a(1115)$, and the theoretical $\varepsilon/\beta^+$ ratio from LOGFT. Other data for the Auger and $\beta^+$ emission were computed with RADLST. For comparison with the adopted value of 1.41% (2) for the $\beta^+$ emission probability, the measured values are:
\[ I_{\beta^+} (%) \]

59Gl55  1.70 (10)
62Be28  1.2  (3)
72De24  1.46 (2)
90Se08  1.42 (2), calculated by evaluator from 511-keV photon emission probability

From the theoretical values of \( \varepsilon/\beta^+ = 34.03 \) and \( K/(L+M+..) = \) the theoretical \( K/\beta^+ \) ratio is 29.28. The corresponding measured values of:

\[
egin{align*}
28.0 (32) & \quad 53Pe14 \\
27.7 (15) & \quad 68Ha47 \\
31.3 (20) & \quad 77Bo10 \\
30.7 (11) & \quad 84ScZP \\
30.3 (10) & \quad 90Ku11 \\
\end{align*}
\]

are in good agreement. The measured 1115-\( \gamma/\beta^+ \) ratio is 35.1 (17) (68Ha47).

### 4.2 Photon Emissions

The \( \gamma \)-ray energies are from evaluation of Helmer et al. (97HeZZ) for the 1115 line where the values are on a scale on which the strong line from the decay of \(^{198}\)Au is 411.80205 (17); from level energy differences for the 344 line; and from \(^{65}\)Cu Adopted \( \gamma \) data in Nuclear Data Sheets (93Bh04) and based on data from \(^{65}\)Ni \( \beta^- \) decay for 770 line.

For the relative and absolute \( \gamma \)-ray emission probabilities, the following data are available:

<table>
<thead>
<tr>
<th>( \gamma )-ray energy (keV)</th>
<th>I(344)</th>
<th>I(770)</th>
<th>I(1115)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60Ri06</td>
<td>\leq 0.5</td>
<td>\leq 1</td>
<td>100</td>
</tr>
<tr>
<td>68St05</td>
<td>0.0060 (6)</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>Absolute</td>
<td>( P(1115) ) (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45Go</td>
<td>46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>59Gl55</td>
<td>51.3 (30)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>63Ta04</td>
<td>50.7 (5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>66Ra21</td>
<td>51.3 (15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>68 HA47</td>
<td>52.4 (10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>72De24</td>
<td>50.75 (10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>73Po10</td>
<td>49.3 (8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>82DeYX</td>
<td>50.39 (26) replaced by 90Se08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90Se08</td>
<td>50.2 (4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adopted</td>
<td>50.60 (22)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The adopted \( P(1115) \) value is from the evaluation of 91BaZS and is from the LRSW analysis of the values from 63Ta04, 66Ra21, 68Ha47, 72De24, 73Po10, and 90Se08. In this analysis the uncertainty of 72De24 is increased from 0.10 to 0.27 to reduce its relative weight from 88% to 50%. If the value of 59Gl55 is included, the LRSW analysis gives the same value, with an internal uncertainty of 0.19, a reduced-\( \chi^2 \) of 1.25, and an external uncertainty of 0.22.

### 6 References

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[T1/2]

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