Title

Precise absolute γ-ray and β−-decay branching intensities in the decay of Cu2967

Journal
Physical Review C, 92(4)

ISSN
2469-9985

Authors
Chen, J
Kondev, FG
Ahmad, I
et al.

Publication Date
2015-10-01

DOI
10.1103/physrevc.92.044330

Peer reviewed

Precise absolute γ-ray and β^--decay branching intensities in the decay of $^{67}_{29}$Cu

J. Chen, F. G. Kondev, I. Ahmad, M. P. Carpenter, J. P. Greene, R. V. F. Janssens, S. Zhu, D. Ehst, V. Makarashvili, D. Rotsch, and N. A. Smith

More

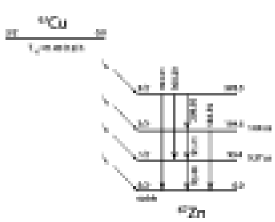
- Article
- References
- Citing Articles (1)

ArticleReferencesCiting Articles (1)

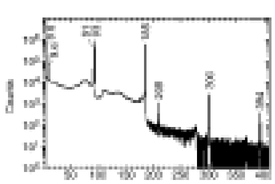
PDFHTMLExport Citation

ABSTRACT

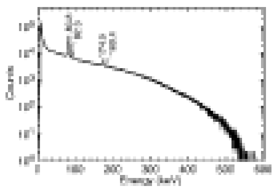
Absolute γ-ray emission probabilities in the β^- decay of ^{67}Cu were measured by means of γ-ray and β^--decay singles and β^-–γ coincidences. The new results, together with the known decay scheme of ^{67}Cu, were used to determine absolute β^--decay branching intensities. The present data differ significantly from previously published values. In addition, the half-life of the $I^\pi=\frac{1}{2}^-$ isomer in ^{67}Znwas measured as $T_{1/2}=9.37(4)$ μs, in a good agreement with earlier measurements. From the analysis of the Fermi–Kurie plots, $Q_{\beta^-}(\text{g.s.})=560.3(10)$ keV was deduced, which differs from the previously measured value of 577(8) keV but is in good agreement with $Q_{\beta^-}(\text{g.s.})=561.3(15)$ keV recommended in the latest Atomic Mass Evaluation.

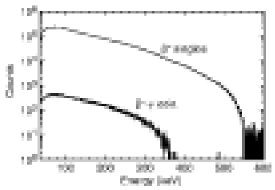


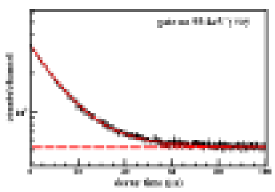
-



-







- Received 8 September 2015

DOI:https://doi.org/10.1103/PhysRevC.92.044330

AUTHORS & AFFILIATIONS

J. Chen[1,*], F. G. Kondev[1,†], I. Ahmad[2], M. P. Carpenter[2], J. P. Greene[2], R. V. F. Janssens[2], S. Zhu[2], D. Ehst[1], V. Makarashvili[1], D. Rotsch[1], and N. A. Smith[1]

- [1]Nuclear Engineering Division, Argonne National Laboratory, Argonne, Illinois 60439, USA
- [2]Physics Division, Argonne National Laboratory, Argonne, Illinois 60439, USA

- [*]Present address: National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, Michigan 48824, USA.
- [†]kondev@anl.gov

ARTICLE TEXT

I. INTRODUCTION

The neutron-rich ^{67}Cu (N=38) nucleus decays by emission of β^- particles to the ground state and to the first three excited levels of the daughter ^{67}Zn nucleus, as indicated in the decay scheme of Fig. 1. Early work of Easterday [1] measured the β^--decay branching intensities, with $I_{\beta_0}\approx 20\%$reported for the ground state to ground state branch. By using this value, the absolute γ-ray emission probabilities were determined in the subsequent γ-ray spectroscopy studies of Raman *et al.* [2] and

Meyer *et al.* [3]. The latter were adopted in the most recent nuclear data evaluation [4]. It should be noted, however, that although the absolute γ-ray intensities in Refs. [3,4] are rather precise, this is somewhat misleading since they are deduced by using the less accurate I_{β_0} value of Easterday [1].

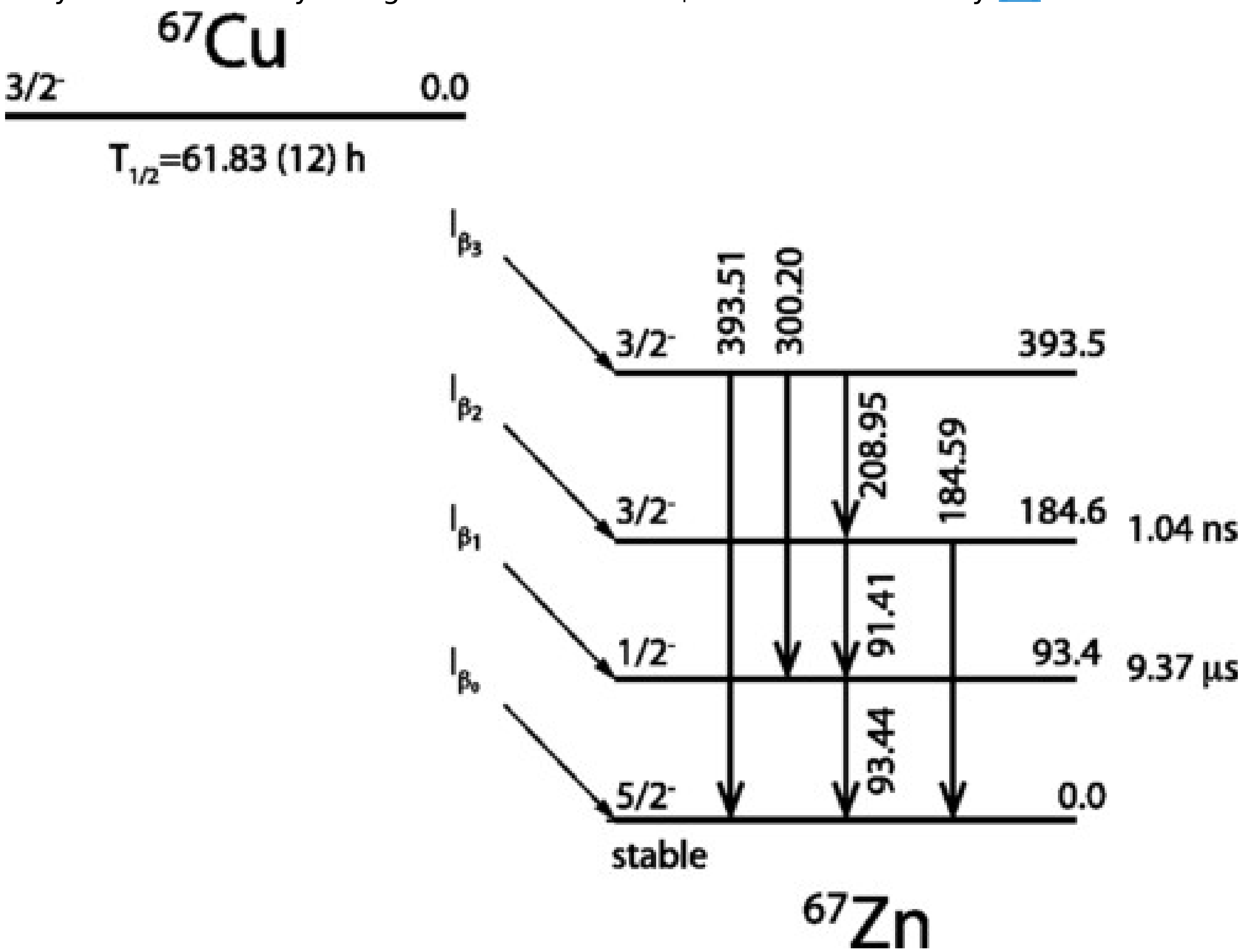


FIG. 1.

+Open in new window

Decay scheme of ^{67}Cu [4]. The γ-ray energies and the half-life of the $I^{\pi}=12^{-}$ level shown the are from the present work.

There are several motivations for a precise knowledge of the absolute decay properties of ^{67}Cu. For example, the β^- decay to the ^{67}Zn ground state involves a $\pi(p_{3/2})^1 \rightarrow \nu[(f_{5/2})^5,(p_{3/2})^4]$ ℓ-forbidden, Gamow–Teller (GT) transition and the precise branching intensity is needed to determine the corresponding $B(GT)$ value that can be used to validate shell-model predictions in this region located near the $N=40$ subshell closure.

The β^- branching intensities are also of interest in measurements of the β-asymmetry parameter in the decay of ^{67}Cu, which can provide information on the search for physics beyond the standard model [5]. Lastly, ^{67}Cu is a promising radionuclide for cancer diagnostics and radio-immunotherapy (see, for example, Ref. [6] and references therein). Although it has favorable decay properties, its wide application is still hampered by difficulties in production and, as a consequence, the lack of reliable supply [7]. Thus, precise knowledge of the absolute γ-ray-emission probability of the strongest 184 keV γ ray is needed in order to accurately determine the resultant activity, and the corresponding production cross sections for this isotope. Other decay properties, such as the absolute β^--decay branching intensities, for example, are important in therapeutic applications and in quantifications of radiation doses.

In this paper, we report on precise measurements of absolute γ-ray emission probabilities in the β^-decay of ^{67}Cu. By using the new data and the adopted decay scheme of ^{67}Cu [4], β^--decay branching intensities were also determined. Our results differ significantly from those reported by the previous measurements [1–4].

II. EXPERIMENTAL DETAILS

III. RESULTS AND DISCUSSIONS

IV. CONCLUSIONS

ACKNOWLEDGMENTS

The authors would like to thank Dr. Yan Cao from the Nuclear Engineering Division at Argonne National Laboratory for her help in the Monte Carlo simulations of detector efficiencies. This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics, under Contract No. DE-AC02-06CH11357. The ^{67}Cu material used in this work was produced using technology developed under a research grant from the U.S. Department of Energy Isotope Program. F.G. Kondev acknowledges support from the Nuclear Data Section of the International Atomic Energy Agency, under the auspices of the Coordinated Research Project on "Nuclear Data for Charged-Particle Monitor Reactions and Medical Isotope Production."

REFERENCES

1. H. T. Easterday, Phys. Rev. **91**, 653 (1953).
2. S. Raman and J. J. Pinajian, Nucl. Phys. A **131**, 393 (1969).
3. R. A. Meyer, A. L. Prindle, W. A. Myers, P. K. Hopke, D. Dieterly, and J. E. Koops, Phys. Rev. C **17**, 1822 (1978).
4. H. Junde, H. Xiaolong, and J. K. Tuli, Nucl. Data Sheets **106**, 159 (2005).
5. G. Soti, F. Wauters, M. Breitenfeldt, P. Finlay, P. Herzog, A. Knecht, U. Koster, I. S. Kraev, T. Porobic, P. N. Prashanth, I. S. Towner, C. Tramm, D. Zakoucky, and N. Severijns, Phys. Rev. C **90**, 035502 (2014).
6. I. Novak-Hofer and P. A. Schubiger, Eur. J. Nucl. Med. **29**, 821 (2002).
7. N. A. Smith, D. L. Bowers, and D. A. Ehst, Appl. Radiat. Isot. **70**, 2377 (2012).

8. N. Marceau, T. P. A. Kruck, D. B. McConnell, and N. Aspin, Int. J. Appl. Radiat. Isot. **21**, 667 (1970).
9. Canberra Industries, Inc., [http://www.canberra.com].
10. J. Anderson, R. Brito, D. Doering, T. Hayden, B. Holmes, J. Joseph, H. Yaver, and S. Zimmermann, in *Proceedings of the Nuclear Science Symposium Conference Record, 2007, NSS'07*, (IEEE, 2007), p. 1751.
11. M. P. Carpenter *et al.*, Bull. Am. Phys. Soc. **56**, GD.00004 (2011).
12. D. C. Radford, Nucl. Instrum. Methods Phys. Res., Sect. A **361**, 297 (1995).
13. Eckert and Ziegler, [http://www.ezag.com].
14. E. Browne and J. K. Tuli, Nucl. Data Sheets **108**, 2173 (2007).
15. E. Browne, Nucl. Data Sheets **98**, 665 (2003).
16. T. Kibédi, T. W. Burrows, M. B. Trzhaskovskaya, P. M. Davidson, and C. W. Nestor Jr., Nucl. Instrum. Methods Phys. Res., Sect. A **589**, 202 (2008).
17. J. K. Tuli and D. F. Winchell, Nucl. Data Sheets **92**, 277 (2001).
18. N. Nica, Nucl. Data Sheets **122**, 1 (2014).
19. D. B. Pelowitz, editor, MCNPX Users Manual Version 2.7.0, LA-CP-11-00438, edited by, 2011.
20. H. F. Schopper, *Weak Interactions and Nuclear Beta Decay* (North-Holland Publishing Company, 1966), p. 45.
21. M. Wang, G. Audi, A. H. Wapstra, F. G. Kondev, M. MacCormick, X. Xu, and B. Pfeiffer, Chin. Phys. C **36**, 1603 (2012).