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## Erratum: Precision mass measurements of $^{67}\text{Fe}$ and $^{69,70}\text{Co}$ : Nuclear structure toward $N = 40$ and impact on $r$ -process reaction rates [Phys. Rev. C **101**, 041304(R) (2020)]

L. Canete , S. Giraud, A. Kankainen , B. Bastin, F. Nowacki, A. Poves, P. Ascher, T. Eronen, V. Alcindor, A. Jokinen, A. Khanam, I. D. Moore, D. A. Nesterenko, F. De Oliveira Santos, H. Penttilä, C. Petrone, I. Pohjalainen, A. de Roubin, V. A. Rubchenya, M. Vilen, and J. Äystö



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In the original paper, we reported on precision mass measurements of neutron-rich Fe and Co isotopes. After the publication, typographical errors were found in the frequency-ratio uncertainties listed in Table I. All mass-excess values and their uncertainties were also rechecked and updated. Only minor changes were found. The uncertainties for the ground and isomeric states of  $^{69}\text{Co}$  were revised and Figs. 2–4 updated accordingly (see Figs. 1–3 of this erratum). The changes in Fig. 5 are negligible and, hence, not updated here. The values reported here (see Table I) should be used instead of Table I of the original paper. The reported changes do not affect the results or conclusions of the paper.

On p. 2 the text should be “The mass-excess values for the longer- and shorter-living states ( $\Delta_{l,s}$ ) were determined from the measured mass-excess values [ $\Delta_{\text{meas}}(t = 226 \text{ ms}) = -50\,296(17)$  and  $\Delta_{\text{meas}}(t = 726 \text{ ms}) = -50\,238(25)$  keV] using  $\Delta_{\text{meas}}(t) = [1 - f_i(t)]\Delta_s + f_i(t)\Delta_l$ . The determined mass-excess value for  $^{69}\text{Co}$ ,  $-50\,385(86)$  keV agrees well with the most recent AME16 [8] value based on measurements using the TOFI spectrometer [10,11],  $B\rho$ -time-of-flight method [12,13], and isochronous mass spectrometry [14]. The obtained mass-excess value for the isomer  $^{69}\text{Co}^m$ ,  $-50\,203(50)$  keV is in perfect agreement with the ground-state value of  $-50\,214(14)$  keV [9], reported recently from the LEBIT Penning trap, suggesting they have actually measured the isomer.”

On p. 3, the text should now be “We have determined the excitation energy  $E_x = 182(100)$  keV for the longer-living ( $1/2^-$ ) state in  $^{69}\text{Co}$  for the first time.”

On p. 4, the text should be “The mass of  $^{69}\text{Co}$  was also found to be around 100 keV lower and 1.6 more precise than in AME16 [8].” On the same page, the  $Q$  value for  $^{68}\text{Co}(n, \gamma)^{69}\text{Co}$  based on our result on  $^{69}\text{Co}$  and  $^{68}\text{Co}$  from Ref. [8] is  $Q = 6.53(21)$  MeV instead of  $Q = 6.52(20)$  MeV in the original paper.

TABLE I. The half-lives, spins, and parities for the ions of interest based on Ref. [15], measured frequency ratios  $r = \nu_{\text{ref}}/\nu$ , and mass-excess values  $\Delta$  in comparison with the literature values from Refs. [8,15]. “#” denotes a value based on extrapolations or systematics. Singly charged ions of  $^{84}\text{Kr}$  ( $m = 83.911\,497\,729(4)u$  [8]) were used as a reference for all studied cases.

| Nuclide            | $T_{1/2}$ (ms) | $I^\pi$           | $r$                          | $\Delta_{\text{JYFL}}$ (keV) | $\Delta_{\text{lit}}$ (keV) | Difference (keV) |
|--------------------|----------------|-------------------|------------------------------|------------------------------|-----------------------------|------------------|
| $^{67}\text{Fe}$   | 394(9)         | $(1/2^-)$         | 0.797874191(49)              | $-45\,709.1(3.8)$            | $-45\,610(270)$             | $-99(270)$       |
| $^{69}\text{Co}$   | 180(20)        | $7/2^- \#$        | 0.82164916(110) <sup>a</sup> | $-50\,385(86)$               | $-50\,280(140)$             | $-105(170)$      |
| $^{69}\text{Co}^m$ | 750(250)       | $1/2^- \#$        | 0.82165149(64) <sup>a</sup>  | $-50\,203(50)$               | $-49\,780(240)\#$           | $-423(250)\#$    |
| $^{70}\text{Co}^b$ | 508(7) [16]    | $(1^+, 2^+) [16]$ | 0.83361594(15)               | $-46\,525(11)$               | $-46\,430(360)\#$           | $-95(360)\#$     |

<sup>a</sup>Calculated based on the isomeric fractions  $f_i$  for the longer-living state and the frequency ratios determined from the files using the 226-ms cycle [ $f_i = 49(13)\%$ ,  $r = 0.82165030(21)$ ] and the 726-ms cycle [ $f_i = 81(9)\%$ ,  $r = 0.82165105(32)$ ], see the text for details.

<sup>b</sup>Assigned as the ground state in Ref. [16]. Considered as a  $3^+ \#$  isomer  $200(200)\#$  keV above a  $(6^-, 7^-)$ ,  $T_{1/2} = 112(7)$ -ms state in Ref. [15].

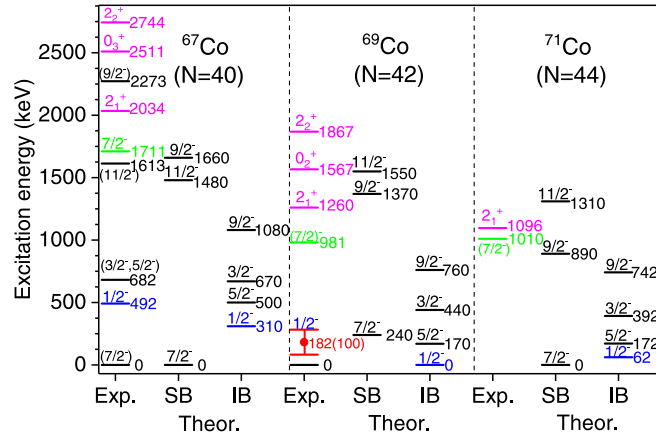


FIG. 1. Revised Fig. 2 of the original paper. Experimental level schemes for  $^{67}\text{Co}$  [1,2] and  $^{69}\text{Co}$  in comparison with the shell-model calculations for the spherical (SB) and  $1/2^-$  intruder (IB) bands in  $^{67,69,71}\text{Co}$ . The  $1/2^-$  states in Co (in blue and in red from the Rapid Communication) follow a similar trend as the  $2^+$  and prolate  $0^+$  [3–6] intruder states in Ni (in magenta) and  $7/2^-$  [7] states in Cu isotones (in green).

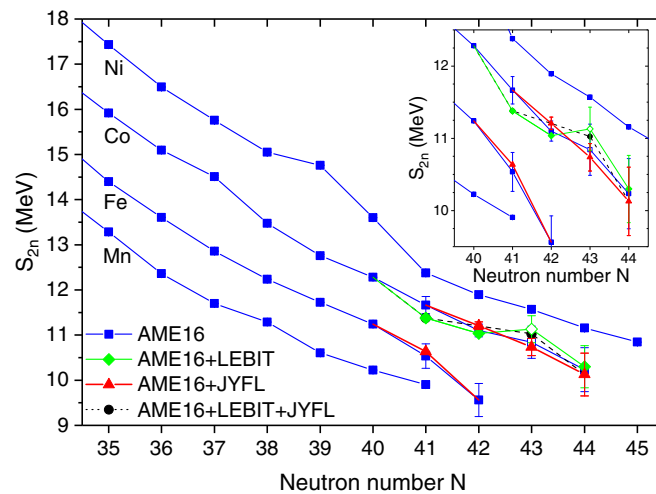


FIG. 2. Revised Fig. 3 of the original paper. Two-neutron separation energies based on experimental values from atomic mass evaluation (AME16) [8] (in blue) and including the results from this erratum (in red). The recent  $^{68,69}\text{Co}$  measurements at LEBIT [9] (in green) introduce a kink, the same is true if only the result for  $^{68}\text{Co}$  from Ref. [9] is included, indicating that it is likely to belong to the isomer  $^{68}\text{Co}^m$ . For  $^{70}\text{Co}$ , AME16 is based on extrapolations (indicated with an open symbol), and our value is for the  $(1^+, 2^+)$  state.

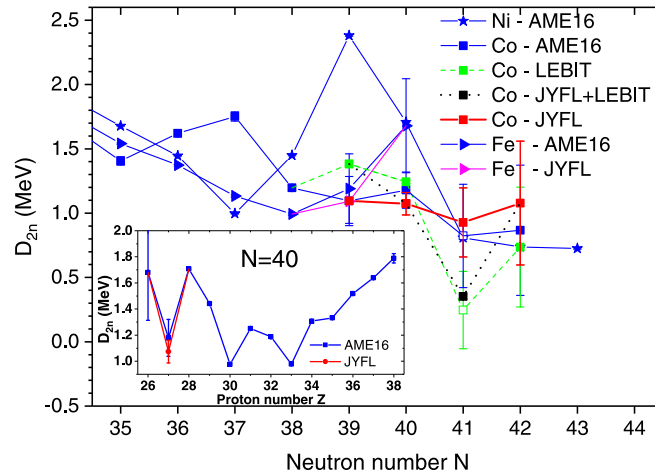


FIG. 3. Revised Fig. 4 of the original publication. Two-neutron shell gap parameter  $D_{2n}(Z, N) = S_{2n}(Z, N) - S_{2n}(Z, N + 2)$  based on AME16 [8] (in blue) and this erratum (red/magenta). Including  $^{68,69}\text{Co}$  from LEBIT [9] (in green), or only  $^{68}\text{Co}$  (in black), results in a kink at  $N = 40$ , pointing toward an isomeric state measurement. The inset shows  $D_{2n}$  for  $N = 40$ .

- [1] D. Pauwels, O. Ivanov, N. Bree, J. Büscher, T. E. Cocolios, J. Gentens, M. Huyse, A. Korgul, Y. Kudryavtsev, R. Raabe *et al.*, *Phys. Rev. C* **78**, 041307(R) (2008).
- [2] F. Recchia, S. M. Lenzi, S. Lunardi, E. Farnea, A. Gadea, N. Mărginean, D. R. Napoli, F. Nowacki, A. Poves, J. J. Valiente-Dobón, M. Axiotis, S. Aydin, D. Bazzacco, G. Benzoni, P. G. Bizzeti, A. M. Bizzeti-Sona, A. Bracco, D. Bucurescu, E. Caubier, L. Corradi, G. de Angelis, F. Della Vedova, E. Fioretto, A. Gottardo, M. Ionescu-Bujor, A. Iordachescu, S. Leoni, R. Mărginean, P. Mason, R. Menegazzo, D. Mengoni, B. Million, G. Montagnoli, R. Orlandi, G. Pollarolo, E. Sahin, F. Scarlassara, R. P. Singh, A. M. Stefanini, S. Szilner, C. A. Ur, and O. Wieland, *Phys. Rev. C* **85**, 064305 (2012).
- [3] C. J. Chiara, D. Weisshaar, R. V. F. Janssens, Y. Tsunoda, T. Otsuka, J. L. Harker, W. B. Walters, F. Recchia, M. Albers, M. Alcorta *et al.*, *Phys. Rev. C* **91**, 044309 (2015).
- [4] C. J. Prokop, B. P. Crider, S. N. Liddick, A. D. Ayangeakaa, M. P. Carpenter, J. J. Carroll, J. Chen, C. J. Chiara, H. M. David, A. C. Dombos *et al.*, *Phys. Rev. C* **92**, 061302(R) (2015).
- [5] F. Flavigny, D. Pauwels, D. Radulov, I. J. Darby, H. De Witte, J. Diriken, D. V. Fedorov, V. N. Fedosseev, L. M. Fraile, M. Huyse *et al.*, *Phys. Rev. C* **91**, 034310 (2015).
- [6] C. Mazzocchi, R. Grzywacz, J. Batchelder, C. Bingham, D. Fong, J. Hamilton, J. Hwang, M. Karny, W. Krolas, S. Liddick *et al.*, *Phys. Lett. B* **622**, 45 (2005).
- [7] S. Franchoo, M. Huyse, K. Kruglov, Y. Kudryavtsev, W. F. Mueller, R. Raabe, I. Reusen, P. Van Duppen, J. Van Roosbroeck, L. Vermeeren *et al.*, *Phys. Rev. C* **64**, 054308 (2001).
- [8] M. Wang, G. Audi, F. Kondev, W. Huang, S. Naimi, and X. Xu, *Chin. Phys. C* **41**, 030003 (2017).
- [9] C. Izzo, G. Bollen, M. Brodeur, M. Eibach, K. Gulyuz, J. D. Holt, J. M. Kelly, M. Redshaw, R. Ringle, R. Sandler *et al.*, *Phys. Rev. C* **97**, 014309 (2018).
- [10] H. L. Seifert, J. M. Wouters, D. J. Vieira, H. Wollnik, X. G. Zhou, X. L. Tu, Z. Y. Zhou, and G. W. Butler, *Z. Phys. A* **349**, 25 (1994).
- [11] Y. Bai, D. J. Vieira, H. L. Seifert, and J. M. Wouters, in *Exotic Nuclei and Atomic Masses (ENAM 98)*, edited by B. M. Sherrill, AIP Conf. Proc. No. 455 (AIP, New York, 1998), p. 90.
- [12] A. Estradé, M. Matoš, H. Schatz, A. M. Amthor, D. Bazin, M. Beard, A. Becerril, E. F. Brown, R. Cyburt, T. Elliot *et al.*, *Phys. Rev. Lett.* **107**, 172503 (2011).
- [13] M. Matoš, A. Estradé, H. Schatz, D. Bazin, M. Famiano, A. Gade, S. George, W. Lynch, Z. Meisel, M. Portillo *et al.*, *Nucl. Instrum. Methods Phys. Res., Sect. A* **696**, 171 (2012).
- [14] X. Xing, W. Meng, Z. Yu-Hu, X. Hu-Shan, S. Peng, T. Xiao-Lin, Y. A. Litvinov, Z. Xiao-Hong, S. Bao-Hua, Y. You-Jin *et al.*, *Chin. Phys. C* **39**, 104001 (2015).
- [15] G. Audi, F. Kondev, M. Wang, W. Huang, and S. Naimi, *Chin. Phys. C* **41**, 030001 (2017).
- [16] A. Morales, G. Benzoni, H. Watanabe, Y. Tsunoda, T. Otsuka, S. Nishimura, F. Browne, R. Daido, P. Doornenbal, Y. Fang *et al.*, *Phys. Lett. B* **765**, 328 (2017).