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$\mathcal{F}t$ values of the $T = 1/2$ mirror β transitions

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A complete survey is presented of all half-life and branching-ratio measurements related to the isospin $T = 1/2$ mirror β transitions ranging from ^{3}He to ^{83}Mo. No measurements are ignored, although some are rejected for cause. Using the decay energies obtained in the 2003 Mass Evaluation experimental ft values are then determined for the transitions up to ^{45}V. For the first time also all associated theoretical corrections needed to convert these results into "corrected" $\mathcal{F}t$ values, similar to the superallowed $0^+ \to 0^+$ pure Fermi β transitions, were calculated. Precisions of the resulting values are in most cases between 0.1 and 0.4%. These $\mathcal{F}t^{\text{mirror}}$ values can now be used to extract precise weak interaction information from past and ongoing correlation measurements in the beta decay of the $T = 1/2$ mirror β transitions.

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I. INTRODUCTION

In the past, several experiments in nuclear β-decay searching for non–standard model contributions to the weak interaction were performed with $T = 1/2$ mirror nuclei [1–10]. Whereas originally the accuracy of these measurements was still rather limited (at best 2%), first precision results were recently obtained with ^{21}Na [9,10], whereas several other experiments are ongoing (with ^{35}Ar [11] and ^{37}K [12]) or in preparation (^{19}Ne [13,14] and ^{21}Na [15]). To extract reliable information from such measurements, precise knowledge of the ft value of the mirror transition under investigation is required. We have therefore performed a thorough survey of all data in the literature related to the ft values of the $T = 1/2$ mirror β transitions and calculated the ft values for the cases up to ^{45}V, thereby updating the previous work of Raman *et al.* [16].

On the experimental side, half-lives ($t_{1/2}$), branching ratios (BR), and Q_{EC} values are required for the determination of ft values. As for the first two, the literature was searched and data were evaluated, leading to adopted values for each isotope. The Q_{EC} values were taken from the 2003 Mass Evaluation [17]. Because for most nuclei up to $A \approx 40$ the experimental data turned out to be sufficiently precise to yield ft values with a precision at the few 10^{-3} level we decided to perform, for the first time for these mirror β transitions, a full analysis of all radiative and nuclear structure corrections leading to the corrected $\mathcal{F}t$ values. Up to now such complete evaluation of the $\mathcal{F}t$ value was only carried out for the superallowed $0^+ \to 0^+$ pure Fermi β transitions [18]. For all $T = 1/2$ mirror nuclei up to ^{45}V $\mathcal{F}t$ values with a precision ranging from 0.10% to about 2.3% were obtained. For the heavier nuclei experimental data are either not available or not sufficiently precise. Nevertheless, all experimental data reported in the literature are listed here.

In a first section the equation for the ft value of an allowed β transition, including all corrections, is derived. From this the equation for the $\mathcal{F}t$ value for the $T = 1/2$ mirror β transitions is then deduced. The next section explains the selection and treatment of the experimental data, whereas the last section deals with the $\mathcal{F}t$ values themselves. At the end of this articles tables are given that list all experimental data and adopted values leading to the $\mathcal{F}t$ values of the $T = 1/2$ mirror transitions, the values for the different correction factors applied for the nuclei up to ^{45}V and, finally, the derived results for the $\mathcal{F}t^{\text{mirror}}$ values.

II. FORMALISM

The decay rate for an allowed β decay from an unpolarized nucleus is written [19]

$$d\Gamma = d\Gamma_0\, \xi \left(1 + \frac{\gamma}{W} b\right), \tag{1}$$

with

$$d\Gamma_0 = \frac{G_F^2 V_{ud}^2}{(2\pi)^5} \frac{1}{(m_e c^2)^5} F(\pm Z, W)\, S(\pm Z, W)(W - W_0)^2 \times pW dW d\Omega_e\, d\Omega_\nu, \tag{2}$$

where W is the total electron energy in electron rest-mass units, W_0 its maximum value, $p = \sqrt{W^2 - 1}$ its momentum, and $m_e c^2$ the electron rest mass. Further, $\gamma = \sqrt{1 - (\alpha Z)^2}$, with α the fine structure constant and Z the charge of the daughter nucleus (taken as positive for electron emission and negative for positron emission), G_F is the fundamental weak interaction coupling constant taken from muon decay, $G_F/(\hbar c)^3 = (1.16639 \pm 0.00001) \times 10^{-5}$ GeV^{-2}, V_{ud} is the up-down quark-mixing element of the Cabibbo-Kobayashi-Maskawa (CKM) matrix, $F(\pm Z, W)$ the Fermi-function, and $S(\pm Z, W)$ the shape-correction function, the value of which is unity in the allowed approximation but whose value differs weakly from one when this approximation is relaxed. In addition, we define

$$\xi = 2\left(M_F^2 C_V^2 + M_{GT}^2 C_A^2\right), \tag{3}$$

where M_F and M_{GT} are the Fermi and Gamow-Teller matrix elements, respectively, and C_V and C_A are the strength of the

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weak vector and axial-vector interactions (in units of G_F) as defined in the Hamiltonian of Jackson, Treiman, and Wyld [19]. We have assumed maximal parity violation for V and A currents. Finally, b is the Fierz interference term [19]. The mean lifetime τ of the decaying state is $\hbar/\Gamma$, which after integrating over neutrino and electron directions, yields

$$\hbar/\tau = \int d\Gamma = \int \frac{G_F^2 V_{ud}^2}{2\pi^3} \frac{1}{(m_e c^2)^5} \xi F(\pm Z, W) \times S(\pm Z, W)(W - W_0)^2 p W \left(1 + \frac{\gamma}{W} b\right) dW. \quad (4)$$

We isolate the partial half-life t by correcting for electron capture competition, P_{EC}, and selecting the branching ratio for the particular transition under study, to obtain

$$1/t = \frac{G_F^2 V_{ud}^2}{2K} \xi f b', \quad (5)$$

with

$$t = \ln 2\tau \left(\frac{1 + P_{\mathrm{EC}}}{\mathrm{BR}}\right), \quad (6)$$

and

$$K/(\hbar c)^6 = \frac{2\pi^3 \ln 2\hbar}{(m_e c^2)^5} = (8120.278 \pm 0.004) \times 10^{-10} \mathrm{GeV}^{-4}\mathrm{s}. \quad (7)$$

The statistical rate function, f, and the Fierz correction factor, b', are defined as

$$f = \int F(\pm Z, W) S(\pm Z, W)(W - W_0)^2 p\, W\, dW \quad (8)$$

$$b' = 1 + \left\langle \frac{\gamma}{W} \right\rangle b. \quad (9)$$

where

$$\left\langle \frac{\gamma}{W} \right\rangle = \frac{1}{f} \int F(\pm Z, W) S(\pm Z, W)(W - W_0)^2 p W \frac{\gamma}{W} dW. \quad (10)$$

Inserting these definitions into Eq. (5), we come to our principal result

$$ft = \frac{2K}{G_F^2 V_{ud}^2} \frac{1}{\xi} \frac{1}{b'}, = \frac{K}{G_F^2 V_{ud}^2} \frac{1}{\left[M_F^2 C_V^2 + M_{\mathrm{GT}}^2 C_A^2\right]} \frac{1}{b'}. \quad (11)$$

We now introduce two classes of small corrections: those due to radiative processes that go undetected in the experiment and those due to isospin not being an exact symmetry in nuclei. Details on the nature of these corrections can, e.g., be found in Ref. [20]. We discuss the radiative corrections first. These are divided into terms that depend on the nucleus in question ("outer radiative correction"), δ_R, and those that do not ("inner radiative correction"), Δ_R:

$$1 + RC = (1 + \delta_R)(1 + \Delta_R). \quad (12)$$

The nuclear-dependent term can be further divided into those pieces that depend trivially on the nucleus, δ'_R (depending only on Z and W_0), and those that require a detailed nuclear-structure calculation, δ_{NS}:

$$1 + RC = (1 + \delta'_R)(1 + \delta_{\mathrm{NS}})(1 + \Delta_R). \quad (13)$$

The δ'_R term is mainly obtained from a standard QED calculation that has been completed to orders α and $Z\alpha^2$ and estimated to order $Z^2\alpha^3$ [21–23]. These three contributions we will call δ_1, δ_2, and δ_3, respectively:

$$\delta'_R = \delta_1 + \delta_2 + \delta_3 + \delta_{\alpha^2}, \quad (14)$$

whereas the δ_{α^2} term is a leading log extrapolation of a low-energy term in the evaluation of the inner radiative correction Δ_R [24] that turned out to be weakly nucleus dependent and was therefore shifted from the inner radiative correction to the outer one [25]. All four contributions in Eq. (14) are the same for both Fermi and Gamow-Teller transitions. By contrast, the contributions δ_{NS} and Δ_R differ between Fermi and Gamow-Teller transitions and so their notation will include a superscript of V or A as required. Details of the calculation of δ_{NS} can be found in Refs. [25–29]. The nucleus-independent radiative correction Δ_R was originally evaluated by Marciano and Sirlin [30] and Sirlin [31], yielding $\Delta_R = 2.40(8)\%$ and has recently been addressed again by Marciano and Sirlin [24], leading to the new value $\Delta_R = (2.361 \pm 0.038)\%$, in agreement with the previous value but a factor of about 2 more precise. The reduction of the central value by approximately 0.04% is due to the fact that the aforementioned term δ_{α^2} was shifted from the inner radiative correction to the outer one.

The Fermi matrix element in the isospin-symmetry limit is precisely known—it is given in terms of an isospin Clebsch-Gordan coefficient. In practice, however, nuclei are impacted by Coulomb and other charge-dependent forces that weakly break the isospin symmetry. So we write

$$M_F^2 = \left|M_F^0\right|^2 \left(1 - \delta_C^V\right), \quad (15)$$

where δ_C^V is the isospin-symmetry breaking correction in Fermi transitions [32,33] and $|M_F^0|^2$ is the isospin symmetry limit value of the matrix element squared given by $|M_F^0|^2 = 2$ for $T = 1 \to T = 1$ transitions and $|M_F^0|^2 = 1$ for $T = 1/2 \to T = 1/2$ transitions. By contrast, the Gamow-Teller matrix element is *not* known in the isospin symmetry limit. Nevertheless, to maintain a consistency in the equations, we write

$$M_{\mathrm{GT}}^2 = \left|M_{\mathrm{GT}}^0\right|^2 \left(1 - \delta_C^A\right), \quad (16)$$

although separate values of the symmetry-limit matrix element, M_{GT}^0, and the symmetry-breaking correction, δ_C^A, are not required for the development here. The isospin-symmetry breaking correction in Fermi transitions, δ_C^V, is typically separated into two components [25]

$$\delta_C^V = \delta_{C1}^V + \delta_{C2}^V, \quad (17)$$

where the first term quantifies the impact of charge-dependent configuration mixing leading to differing wave functions for the parent and daughter nuclei, whereas the second term accounts for the differences in the single-particle neutron and proton radial wave functions, which cause the radial overlap integral of the parent and daughter nucleus to be less than unity.

Including now all corrections, and noting the shape-correction function $S(\pm Z, W)$ in the statistical rate function differs between Fermi and Gamow-Teller transitions, we have (setting $b' = 1$)

$$t = \frac{K}{G_F^2 V_{ud}^2} \frac{1}{(1+\delta'_R)\left[f_V \left|M_F^0\right|^2 \left(1+\delta_{\rm NS}^V-\delta_C^V\right) C_V^2 \left(1+\Delta_R^V\right) + f_A \left|M_{\rm GT}^0\right|^2 \left(1+\delta_{\rm NS}^A-\delta_C^A\right) C_A^2 \left(1+\Delta_R^A\right)\right]}. \qquad (18)$$

For the superallowed $0^+ \rightarrow 0^+$ pure Fermi transitions, with $|M_F^0|^2 = 2$ and $M_{\rm GT}^0 = 0$, one then has

$$f_V t^{0^+\rightarrow 0^+} = \frac{K}{2G_F^2 V_{ud}^2} \frac{1}{(1+\delta'_R)\left(1+\delta_{\rm NS}^V-\delta_C^V\right) C_V^2 \left(1+\Delta_R^V\right)} \qquad (19)$$

or

$$\begin{aligned} \mathcal{F}t^{0^+\rightarrow 0^+} &\equiv f_V t^{0^+\rightarrow 0^+} (1+\delta'_R)\left(1+\delta_{\rm NS}^V-\delta_C^V\right) \\ &= \frac{K}{2G_F^2 V_{ud}^2 C_V^2 \left(1+\Delta_R^V\right)}. \end{aligned} \qquad (20)$$

For a mixed Fermi and Gamow-Teller transition, we can recast Eq. (18) into the form

$$\begin{aligned} & f_V t (1+\delta'_R)\left(1+\delta_{\rm NS}^V-\delta_C^V\right) \\ &= \frac{K}{G_F^2 V_{ud}^2} \frac{1}{\left|M_F^0\right|^2 C_V^2 \left(1+\Delta_R^V\right)\left(1+\frac{f_A}{f_V}\rho^2\right)}, \\ &= \frac{2\mathcal{F}t^{0^+\rightarrow 0^+}}{\left|M_F^0\right|^2 \left(1+\frac{f_A}{f_V}\rho^2\right)}, \end{aligned} \qquad (21)$$

where a mixing ratio is defined as

$$\rho = \frac{C_A M_{\rm GT}^0}{C_V M_F^0} \left[\frac{\left(1+\delta_{\rm NS}^A-\delta_C^A\right)\left(1+\Delta_R^A\right)}{\left(1+\delta_{\rm NS}^V-\delta_C^V\right)\left(1+\Delta_R^V\right)}\right]^{1/2} \simeq \frac{C_A M_{\rm GT}^0}{C_V M_F^0}. \qquad (22)$$

Last, restricting our attention to the $T = 1/2$ mirror β transitions, for which $|M_F^0|^2 = 1$, Eq. (21) reduces to

$$\mathcal{F}t^{\rm mirror} \equiv f_V t \left(1+\delta'_R\right)\left(1+\delta_{\rm NS}^V-\delta_C^V\right) = \frac{2\mathcal{F}t^{0^+\rightarrow 0^+}}{\left(1+\frac{f_A}{f_V}\rho^2\right)}. \qquad (23)$$

This is our master equation. Our goal now is to extract values of the mixing ratio squared ρ^2 using data on the partial half-lives, t, for mirror transitions in odd-mass nuclei. To this end we need apart from experimental data also calculations of the statistical rate function, f_V and the ratio f_A/f_V, the nucleus-dependent radiative corrections, δ'_R and $\delta_{\rm NS}^V$, and the isospin-symmetry breaking correction, δ_C^V. Further, we take the current best value of $\mathcal{F}t^{0^+\rightarrow 0^+}$ from the most recent work of Towner and Hardy [25].

III. EXPERIMENTAL DATA

To determine the ft value for a β transition three measured quantities are required: the half-life, $t_{1/2}$, of the parent state; the branching ratio of the particular transition of interest; and the total transition energy, $Q_{\rm EC}$. The half-life and the branching ratio combine to yield the partial half-life, t, [Eq. (6)], whereas the $Q_{\rm EC}$ value is required to determine the statistical rate function, f, [Eq. (8)]. In our treatment of the data all half-life and branching ratio measurements published before January 2008 are considered. Because the evaluation of the $Q_{\rm EC}$ values from different types of measurements would be too vast a project in itself it was decided to rely for these on the very extended 2003 Mass Evaluation [17]. Half-life and branching ratio data are available for mirror nuclei up to ^{83}Mo. All original experimental data were checked in detail. In Tables I and II we present all measured values for the half-life and the branching ratio that were used in our analysis. References to these data are listed in Tables III and IV. Each datum appearing in these tables is attributed to its original journal reference via an alphanumeric code comprising the initial two letters of the first author's name and the last two digits of the publication date. If data were obviously wrong they were rejected. All rejected data are listed in Tables V and VI, with the reason for this rejection.

Similar evaluation principles and statistical procedures as those that are adopted for the analysis of the superallowed $0^+ \rightarrow 0^+$ pure Fermi transitions [18] were used. Thus, of the surviving results, only those with uncertainties that are within a factor of 10 of the most precise measurement for each quantity were retained for averaging in the tables.

The statistical procedures followed in analyzing the tabulated data are based on those used by the Particle Data Group in their periodic reviews of particle properties (e.g., Ref. [34]). In the tables and throughout this work, "error bars" and "uncertainties" always refer to ±1 standard deviation (68% confidence level).

For a set of N independent measurements, $x_i \pm \delta x_i$, of a particular quantity, a Gaussian distribution is assumed, the weighted average being calculated according to the equation

$$\bar{x} \pm \delta\bar{x} = \frac{\sum_i w_i x_i}{\sum_i w_i} \pm \left(\sum_i w_i\right)^{-1/2}, \qquad (24)$$

where

$$w_i = 1/(\delta x_i)^2 \qquad (25)$$

TABLE I. Half-lives, $t_{1/2}$, of the mirror nuclei, expressed in seconds unless specified differently under the name of the parent nucleus (days (d), minutes (min)). References to data listed in this table are given in Table III. References to data that were not used are listed in Table V together with the reason for their rejection. The scale factor S listed in the last column is defined in Eq. (26).

Parent nucleus	Measured half-lives, $t_{1/2}$ (s)								Average half-life $t_{1/2}(s)$	scale S
	1		2		3		4			
^{3}H	4419 ± 183	[No47]	4551 ± 54	[Je50]	4530 ± 27	[Jo51]	4479 ± 11	[Jo55]		
(d)	4596 ± 66	[Po58]	4496 ± 16	[Me66]	4474 ± 11	[Jo67]	4501 ± 9	[Ru77]		
	4498 ± 11	[Si87]	4521 ± 11	[Ol87]	4485 ± 12	[Ak88]	4497 ± 11	[Bu91]		
	4504 ± 9	[Un00]	4500 ± 8	[Lu00]	4479 ± 7	[Ak04]	4497 ± 4	[Ma06]	4497 ± 4 d[a]	
^{11}C	20.35 ± 0.08	[Sm41]	20.0 ± 0.1	[Di51]	20.74 ± 0.10	[Ku53]	20.26 ± 0.10	[Ba55]		
(min)	20.8 ± 0.2	[Pr57]	20.11 ± 0.13	[Ar58]	20.34 ± 0.04	[Ka64a]	20.40 ± 0.04	[Aw69]		
	20.38 ± 0.02	[Az75]	20.32 ± 0.12	[Be75]	20.334 ± 0.024	[Wo02]			20.360 ± 0.026 min	2.0
^{13}N	9.96 ± 0.03	[Ar58]	9.965 ± 0.005	[Ja60]	9.93 ± 0.05	[Ki60]	10.05 ± 0.05	[Bo65]		
(min)	9.96 ± 0.02	[Eb65]	9.963 ± 0.009	[Ri68]	9.965 ± 0.010	[Az77]			9.9647 ± 0.0039 min	1
^{15}O	123.95 ± 0.50	[Pe57]	124.1 ± 0.5	[Ki59]	122.1 ± 0.1	[Ja60]	122.6 ± 1.0	[Ne63]		
	122.23 ± 0.23	[Az77]							122.24 ± 0.27	3.0
^{17}F	65.2 ± 0.2	[Wo69]	64.50 ± 0.25	[Al72]	64.31 ± 0.09	[Az77]	64.80 ± 0.09	[Al77]	64.61 ± 0.17	2.9
^{19}Ne	17.7 ± 0.1	[Pe57]	17.43 ± 0.06	[Ea62]	17.36 ± 0.06	[Go68]	17.36 ± 0.06	[Wi74]		
	17.219 ± 0.017	[Az75]	17.237 ± 0.014	[Pi85]					17.248 ± 0.029	2.8
^{21}Na	23.0 ± 0.2	[Ar58]	22.55 ± 0.10	[Al74]	22.47 ± 0.03	[Az75]			22.487 ± 0.054	1.9
^{23}Mg	12.1 ± 0.1	[Mi58]	11.41 ± 0.05	[Go68]	11.36 ± 0.04	[Al74]	11.26 ± 0.08	[Az74]		
	11.327 ± 0.014	[Az75]	11.317 ± 0.011	[Az77]					11.3243 ± 0.0098[b]	1.2
^{25}Al	7.24 ± 0.03	[Mu58]	7.23 ± 0.02	[Ju71]	7.177 ± 0.023	[Ta73]	7.174 ± 0.007	[Az75]	7.182 ± 0.012	1.9
^{27}Si	4.14 ± 0.03	[Mi58]	4.16 ± 0.03	[Su62]	4.19 ± 0.02	[Bl68]	4.17 ± 0.01	[Go68]		
	4.21 ± 0.03	[Gr71]	4.109 ± 0.004	[Az75]	4.206 ± 0.008	[Ge76]	4.09 ± 0.02	[Ba77]	4.135 ± 0.019	6.0
^{29}P	4.19 ± 0.02	[Ja60]	4.15 ± 0.03	[Sc70]	4.149 ± 0.005	[Ta73]	4.083 ± 0.012	[Az75]		
	4.084 ± 0.022	[Wi80]							4.140 ± 0.016	3.6
^{31}S	2.66 ± 0.03	[Ha52]	2.40 ± 0.07	[Hu54]	2.80 ± 0.05	[Cl58]	2.72 ± 0.02	[Mi58]		
	2.57 ± 0.01	[Ja60]	2.61 ± 0.05	[Li60]	2.58 ± 0.06	[Wa60]	2.605 ± 0.012	[Al74]		
	2.543 ± 0.008	[Az77]	2.562 ± 0.007	[Wi80]					2.574 ± 0.017[c]	4.2
^{33}Cl	2.53 ± 0.02	[Mu58]	2.51 ± 0.02	[Ja60]	2.47 ± 0.02	[Sc70]	2.513 ± 0.004	[Ta73]		
	2.507 ± 0.008	[Az77]							2.5111 ± 0.0040	1.2
^{35}Ar	1.79 ± 0.01	[Ja60]	1.770 ± 0.006	[Wi69]	1.774 ± 0.003	[Az77]	1.7754 ± 0.0011	[Ia06]	1.7752 ± 0.0010	1
^{37}K	1.23 ± 0.02	[Sc58]	1.25 ± 0.04	[Ka64]	1.223 ± 0.008	[Az77]			1.2248 ± 0.0073	1
^{39}Ca	0.90 ± 0.01	[Kl54]	0.876 ± 0.012	[Cl58]	0.860 ± 0.005	[Mi58]	0.873 ± 0.008	[Li60]		
	$0.865^{+0.007}_{-0.017}$	[Ka68][e]	0.8604 ± 0.0030	[Al73]	0.8594 ± 0.0016	[Az77]			0.8609 ± 0.0028	2.2
^{41}Sc	0.628 ± 0.014	[Ja60]	0.596 ± 0.006	[Yo65]	0.5963 ± 0.0017	[Al73]	0.591 ± 0.005	[Ta73]	0.5962 ± 0.0022	1.4
^{43}Ti	0.58 ± 0.04	[Sc48]	0.528 ± 0.003	[Ja60]	0.56 ± 0.02	[Ja61]	0.50 ± 0.02	[Pl62]		
	0.40 ± 0.05	[Va63]	0.49 ± 0.01	[Al67]	0.54 ± 0.01	[Va69]	0.509 ± 0.005	[Ho87]	0.5222 ± 0.0057[d]	2.4
^{45}V	0.539 ± 0.018	[Ho82]	0.5472 ± 0.0053	[Ha87]					0.5465 ± 0.0051	1
^{47}Cr	0.4600 ± 0.0015	[Ed77]	0.508 ± 0.010	[Bu85]	0.4720 ± 0.0063	[Ha87]			0.4616 ± 0.0051	3.6
^{49}Mn	0.384 ± 0.017	[Ha80]	0.3817 ± 0.0074	[Ha87]					0.3821 ± 0.0068	1
^{51}Fe	0.310 ± 0.005	[Ay84]	0.3050 ± 0.0043	[Ha87]					0.3071 ± 0.0033	1
^{53}Co	0.262 ± 0.025	[Ko73]	0.240 ± 0.025	[Ho89]	0.267 ± 0.025	[Ha87]	0.240 ± 0.009	[Lo02]	0.2446 ± 0.0076	1
^{55}Ni	0.189 ± 0.005	[Ho77]	0.208 ± 0.005	[Ay84]	0.2121 ± 0.0038	[Ha87]	0.204 ± 0.003	[Re99]		
	0.196 ± 0.005	[Lo02]							0.2033 ± 0.0037	2.0
^{57}Cu	0.1994 ± 0.0032	[Sh89]	0.1963 ± 0.0007	[Se96]					0.19644 ± 0.00068	1
^{59}Zn	0.1820 ± 0.0018	[Ar84]	0.173 ± 0.014	[Lo02]					0.1819 ± 0.0018	1
^{61}Ga	0.15 ± 0.03	[Wi93]	0.168 ± 0.003	[We02]	0.148 ± 0.019	[Lo02]			0.1673 ± 0.0029	1
^{63}Ge	$0.095^{+0.023}_{-0.025}$	[Wi93][e]	$0.095^{+0.023}_{-0.020}$	[Sh93][e]	0.150 ± 0.009	[Lo02]			0.137 ± 0.016	2.1
^{65}As	$0.19^{+0.11}_{-0.07}$	[Wi93][e]	0.190 ± 0.011	[Mo95]	0.126 ± 0.016	[Lo02]			0.170 ± 0.030	3.3
^{67}Se	0.107 ± 0.035	[Ba94]	$0.060^{+0.017}_{-0.011}$	[Bl95][e]	0.136 ± 0.012	[Lo02]			0.106 ± 0.024	2.7
^{71}Kr	0.097 ± 0.009	[Ew81]	$0.064^{+0.008}_{-0.005}$	[Bl95][e]	0.100 ± 0.003	[Oi97]			0.0944 ± 0.0086	3.3
^{75}Sr	0.088 ± 0.003	[Hu03]							0.088 ± 0.003	
^{77}Y	$0.057^{+0.022}_{-0.012}$	[Ki01][e]							0.065 ± 0.017	
^{79}Zr	0.056 ± 0.030	[Bl99]							0.056 ± 0.030	
^{83}Mo	$0.006^{+0.030}_{-0.003}$	[Ki01][e]							0.028 ± 0.019	

[a] We did not perform the analysis of the tritium half-lives ourselves, but rather used the value (and the references) from [Ma06]. An interesting effect is mentioned in [Ak04]; the half-life of molecular and atomic ^{3}H would differ by about 9 days. Due to a lack of additional information on this (recently observed) effect we have not included it in the present compilation. All measurements, except for [Ak04], have been performed on molecular tritium.

[b] The weighted average including [Mi58] is 11.330 ± 0.30 s, compared to 11.3243 ± 0.0098 s without [Mi58], both with scaling. Because (Mi58] has a strongly deviating value, it was decided to drop this result.

[c] Note that without [Mi58], the central value of which differs from later results, the weighted average becomes 2.567 ± 0.011 s.

[d] The weighted average discarding [Ja60] is 0.5124 ± 0.0085 s, compared to 0.5222 ± 0.0057 s, both with scaling included. Because there is no clear reason to drop [Ja60] it was decided to keep it. Note that this is the most precise result, yet it dates from 1960.

[e] These asymmetric errors have been symmetrized for the analysis by using standard recommendations of the Particle Data Group.

TABLE II. Branching ratios, BR, for the $T = 1/2$ mirror β transitions. References to data listed here are given in Table IV. References to rejected data are listed in Table VI.

Parent nucleus	Measured branching ratio, BR (%)						Average value BR%	scale S
	1		2		3			
^{3}H	100	[Ti87]					100	
^{11}C	100	[Aj75]					100	
^{13}N	100	[Aj70]					100	
^{15}O	100	[Aj70]					100	
^{17}F	100	[Aj70]					100	
^{19}Ne	BR(1.55 MeV):		0.0021 ± 0.0003	[Al76]	0.0023 ± 0.0003	[Ad83]		
	BR(0.11 MeV):		0.012 ± 0.002	[Ad81]	0.011 ± 0.009	[Sa93]	99.9858 ± 0.0020	1
^{21}Na	94.9 ± 0.2	[Al74]	95.8 ± 0.2	[Az77]	94.98 ± 0.13	[Wi80]		
	95.26 ± 0.04	[Ia06]	95.15 ± 0.12	[Ac07]			95.235 ± 0.069	2.0
^{23}Mg	90.9 ± 0.5	[Ta60]	91.4 ± 0.4	[Go68a]	90.9 ± 0.4	[Al74]		
	91.9 ± 0.4	[Ma74]	92.2 ± 0.2	[Az77]			91.78 ± 0.26	1.8
^{25}Al	99.16 ± 0.07	[Ju71]	99.1 ± 0.2	[Ma69]	99.11 ± 0.08	[Ma76]		
	99.16 ± 0.04	[Az77]					99.151 ± 0.031	1
^{27}Si	99.90 ± 0.02	[Go64]	99.80 ± 0.07	[De71]	99.82 ± 0.05	[Be71]		
	99.77 ± 0.02	[Ma74]	99.81 ± 0.01	[Az77]			99.818 ± 0.022	2.8
^{29}P	98.4 ± 0.3	[Lo62]	98.11 ± 0.30	[Az77]	98.29 ± 0.03	[Wi80]	98.290 ± 0.030	1
^{31}S	98.9 ± 0.1	[Ta60]	99.2 ± 0.4	[De71]	98.75 ± 0.06	[Al74]		
	98.89 ± 0.20	[Az77]	98.86 ± 0.04	[Wi80]			98.837 ± 0.031	1
^{33}Cl	98.3 ± 0.2	[Ba70]	98.58 ± 0.19	[Wi80]			98.45 ± 0.14	1
^{35}Ar	98.32 ± 0.07	[Wi69]	98.55 ± 0.05	[De71]	98.3 ± 0.2	[Ge71]		
	98.0 ± 0.2	[Az77]	98.24 ± 0.05	[Wi80]	98.24 ± 0.10	[Ad84]	98.358 ± 0.066	2.2
^{37}K	98.0 ± 0.4	[Ka64]	98.5 ± 0.2	[Ma76]	97.8 ± 0.2	[Az77]		
	97.89 ± 0.11	[Ha97]					97.99 ± 0.14	1.7
^{39}Ca	99.9975 ± 0.0002	[Ha94]					99.9975 ± 0.0002	
^{41}Sc	99.963 ± 0.003	[Wi80]					99.963 ± 0.003	
^{43}Ti	90.2 ± 0.8	[Ho87]					90.2 ± 0.8	
^{45}V	95.7 ± 1.5	[Ho82]					95.7 ± 1.5	
^{47}Cr	96.3 ± 1.2	[Bu85]					96.3 ± 1.2	
^{49}Mn	93.6 ± 2.6	[Ha80]	91.9 ± 2.8	[Ho89]			92.8 ± 1.9	1
^{51}Fe	95.0 ± 1.3	[Ay84]	93.8 ± 1.3	[Ho89]			94.40 ± 0.92	1
^{53}Co	94.4 ± 1.7	[Ho89]					94.4 ± 1.7	
^{57}Cu	89.9 ± 0.8	[Se96]					89.9 ± 0.8	
^{59}Zn	93.0 ± 3.0	[Ho81]	94.1 ± 0.8	[Ar84]			94.03 ± 0.77	1
^{61}Ga	94 ± 1	[We02]					94 ± 1	
^{71}Kr	82.1 ± 1.6	[Oi97]					82.1 ± 1.6	
^{75}Sr	$90.3^{+1.9}_{-2.8}$	[Hu03][a]					89.6 ± 2.4	

[a] These asymmetric errors have been symmetrized for the analysis by using standard recommendations of the Particle Data Group.

and the sums extend over all N measurements. For each average the χ^2 is also calculated and a scale factor, S, determined from

$$S = [\chi^2/(N-1)]^{1/2}. \tag{26}$$

This factor is then used to establish the quoted uncertainty. If $S \leqslant 1$, the value of $\delta\bar{x}$ from Eq. (24) is left unchanged. If $S > 1$ and the input δx_i are all about the same size, then $\delta\bar{x}$ is increased by the factor S, which is equivalent to assuming that

TABLE III. References to data used in the calculation of the half-lives, $t_{1/2}$, of the $T = 1/2$ mirror nuclei.

Code	Authors	Reference	Measured nuclei
[Ak04]	Y. A. Akulov *et al.*	Phys. Lett. **B600**, 41 (2004)	^{3}H
[Ak88]	Y. A. Akulov *et al.*	Pis'ma Zh. Tekh. Fiz. **14**, 940–942 (1988). English translation: Sov. Tech. Phys. Lett. **14**, 416 (1988)	^{3}H
[Al67]	A. M. Aldridge *et al.*	Nucl. Phys. **A98**, 323(1967)	^{43}Ti
[Al72]	D. E. Alburger, D. H. Wilkinson	Phys. Rev. C **6**, 2019 (1972)	^{17}F
[Al73]	D. E. Alburger, D. H. Wilkinson	Phys. Rev. C **8**, 657 (1973)	^{39}Ca, ^{41}Sc
[Al74]	D. E. Alburger	Phys. Rev. C **9**, 991 (1974)	^{21}Na, ^{23}Mg, ^{31}S
[Al77]	D. E. Alburger	Phys. Rev. C **16**, 889 (1977)	^{17}F
[Ar58]	S. E. Arnell *et al.*	Nucl. Phys. **6**, 196 (1958)	^{11}C, ^{13}N, ^{21}Na
[Ar84]	Y. Arai *et al.*	Nucl. Phys. **A420**, 193 (1984)	^{59}Zn
[Aw69]	M. Awschalom *et al.*	Nucl. Instr. Methods **75**, 93 (1969)	^{11}C
[Ay84]	J. Äystö *et al.*	Phys. Lett. **B138**, 369–372 (1984)	^{51}Fe, ^{55}Ni
[Az74]	G. Azuelos *et al.*	Nucl. Instrum. Methods **117**, 233 (1974)	^{23}Mg
[Az75]	G. Azuelos, J. E. Kitching	Phys. Rev. C **12**, 563 (1975)	^{11}C, ^{19}Ne, ^{21}Na, ^{23}Mg, ^{25}Al, ^{27}Si, ^{29}P

TABLE III. *(Continued.)*

Code	Authors	Reference	Measured nuclei
[Az77]	G. Azuelos *et al.*	Phys. Rev. C **15**, 1847 (1977)	^{13}N, ^{15}O, ^{17}F, ^{23}Mg, ^{31}S, ^{33}Cl, ^{35}Ar, ^{37}K, ^{39}Ca
[Ba55]	S. Bashkin *et al.*	Phys. Rev. **99**, 107 (1955)	^{11}C
[Ba77]	P. H. Barker *et al.*	Nucl. Phys. **A275**, 37 (1977)	^{27}Si
[Ba94]	P. Baumann *et al.*	Phys. Rev. C **50**, 1180 (1994)	^{67}Se
[Be75]	H. Behrens *et al.*	Nucl. Phys. **A246**, 317 (1975)	^{11}C
[Bl68]	J. L. Black, J. Mahieux	Nucl. Instr. Methods **58**, 93 (1968)	^{27}Si
[Bl95]	B. Blank *et al.*	Phys. Lett. **B364**, 8 (1995)	^{67}Se, ^{71}Kr
[Bl99]	B. Blank	J. Phys. G **25**, 629 (1999)	^{79}Zr
[Bo65]	M. Bormann *et al.*	Nucl. Phys. **63**, 438 (1965)	^{13}N
[Bu85]	T. W. Burrows *et al.*	Phys. Rev. C **31**, 1490 (1985)	^{47}Cr
[Bu91]	B. Budick *et al.*	Phys. Rev. Lett. **67**, 2630–2633 (1991)	^{3}H
[Cl58]	J. E. Cline, P. R. Chagnon	Bull. Am. Phys. Soc. 3, No. 3, 206, RA5 (1958)	^{31}S, ^{39}Ca
[Di51]	J. M. Dickson, T. C. Randle	Proc. Phys. Soc. (London) **64**A, 902 (1951)	^{11}C
[Ea62]	L. G. Earwaker *et al.*	Nature **195**, 271 (1962)	^{19}Ne
[Eb65]	T. G. Ebrey, P. R. Gray	Nucl. Phys. **61**, 479 (1965)	^{13}N
[Ed77]	M. D. Edmiston *et al.*	Nucl. Instrum. Methods **141**, 315 (1977)	^{47}Cr
[Ew81]	G. T. Ewan *et al.*	Nucl. Phys. **A352**, 13 (1981)	^{71}Kr
[Ge76]	H. Genz *et al.*	Nucl. Instrum. Methods **134**, 309 (1976)	^{27}Si
[Go68]	J. D. Goss *et al.*	Nucl. Phys. **A115**, 113 (1968)	^{19}Ne, ^{23}Mg, ^{27}Si
[Gr71]	D. Grober, W. Gruhle	BMBW-FBK-71-09, p. 90 (1971)	^{31}Si
[Ha52]	R. N. H. Haslam *et al.*	Can. J. Phys. **30**, 257 (1952)	^{31}S
[Ha80]	J. C. Hardy *et al.*	Phys. Lett. **B91**, 207 (1980)	^{49}Mn
[Ha87]	H. Hama *et al.*	Proc. 5th Int. Conf. Nuclei far from Stability, Rosseau Lake, Canada 1987, I. S. Towner, ed., p. 650 (1988)	^{45}V, ^{47}Cr, ^{49}Mn, ^{51}Fe, ^{53}Co, ^{55}Ni
[Ho77]	P. Hornshoj *et al.*	Nucl. Phys. **A288**, 429 (1977)	^{55}Ni
[Ho82]	P. Hornshoj *et al.*	Phys. Lett. **B116**, 4 (1982)	^{45}V
[Ho87]	J. Honkanen *et al.*	Nucl. Phys. **A471**, 489 (1987)	^{43}Ti
[Ho89]	J. Honkanen *et al.*	Nucl. Phys. **A496**, 462 (1989)	^{53}Co
[Hu03]	J. Huikari *et al.*	Eur. Phys. J. A **16**, 359 (2003)	^{75}Sr
[Hu54]	S. E. Hunt *et al.*	Phys. Rev. **95**, 611A (1954)	^{31}S
[Ia06]	V. E. Iacob *et al.*	Phys. Rev. C **74**, 055502 (2006)	^{35}Ar
[Ja60]	J. Janecke	Z. Naturforsch. **15a**, 593 (1960)	^{13}N, ^{15}O, ^{29}P, ^{31}S, ^{33}Cl, ^{35}Ar, ^{41}Sc, ^{43}Ti
[Ja61]	J. Janecke, H. Jung	Z. Phys. **165**, 94 (1961)	^{43}Ti
[Je50]	G. H. Jenks *et al.*	Phys. Rev. **80**, 990–995 (1950)	^{3}H
[Jo51]	W. M. Jones	Phys. Rev. **83**, 537–539 (1950)	^{3}H
[Jo55]	W. M. Jones	Phys. Rev. **100**, 124–125 (1955)	^{3}H
[Jo67]	P. M. S. Jones	J. Nucl. Mater. **21**, 239–240 (1967)	^{3}H
[Ju71]	F. Jundt *et al.*	Nucl. Phys. **A170**, 12 (1971)	^{25}Al
[Ka64]	R. W. Kavanagh, D. R. Goosman	Phys. Lett. **12**, 229 (1964); Erratum Phys. Lett. **13**, 358 (1964)	^{37}K
[Ka64a]	R. W. Kavanagh *et al.*	Can. J. Phys. **42**, 1429 (1964)	^{11}C
[Ka68]	J. A. Kadlecek	Bull. Am. Phys. Soc. **13**, 676, HF15 (1968)	^{39}Ca
[Ki01]	K. Kienle *et al.*	Prog. Part. Nucl. Phys. **46**, 73 (2001)	^{77}Y, ^{79}Zr, ^{83}Mo
[Ki59]	O. C. Kistner, B. M. Rustad	Phys. Rev. **114**, 1329 (1959)	^{15}O
[Ki60]	J. D. King *et al.*	Can. J. Phys. **38**, 231 (1961)	^{13}N
[Kl54]	R. M. Kline, D. J. Zaffarano	Phys. Rev. 96, 1620 (1954)	^{39}Ca
[Ko73]	S. Kochan *et al.*	Nucl. Phys. **A204**, 185 (1973)	^{53}Co
[Ku53]	D. N. Kundu *et al.*	Phys. Rev. **89**, 1200 (1953)	^{11}C
[Li60]	K. H. Lindenberger, J. A. Scheer	Z. Physik **158**, 111 (1960)	^{31}S, ^{39}Ca
[Lo02]	M. Lopez-Jimenez, B. Blank *et al.*	Phys. Rev. C **66**, 025803 (2002)	^{53}Co, ^{55}Ni, ^{57}Cu, ^{59}Zn, ^{61}Ga, ^{63}Ge, ^{65}As, ^{67}Se, ^{71}Kr
[Lu00]	L. L. Lucas and M. P. Unterweger	J. Res. Natl. Inst. Stand. Technol. **105**, 541 (2000)	^{3}H
[Ma06]	D. MacMahon	Appl. Rad. Isot. **64**, 1417–1419 (2006)	^{3}H
[Me66]	J. S. Merritt and J. G. V. Taylor	Report AECL-2510, Atomic Energy of Canada Limited, Chalk River Laboratory, Chalk River, Ontario (1966), p. 28	^{3}H
[Mi58]	M. V. Mihailovic, B. Povh	Nuclear Phys. **7**, 296 (1958)	^{27}Si, ^{39}Ca
[Mo95]	D. J. Morrissey	Nucl. Phys. **A588**, c203 (1995)	^{65}As
[Mu58]	T. Muller *et al.*	Physica **24**, 577 (1958)	^{25}Al, ^{33}Cl
[Ne63]	J. W. Nelson *et al.*	Phys. Rev. **129**, 1723 (1963)	^{15}O, ^{31}S, ^{35}Ar
[No47]	A. Novick	Phys. Rev. **72**, 972 (1947)	^{3}H
[Oi97]	M. Oinonen *et al.*	Phys. Rev. C **56**, 745 (1997)	^{71}Kr
[Ol87]	B. M. Oliver *et al.*	Appl. Radiat. Isot. **38**, 959–965 (1987)	^{3}H
[Pe57]	J. R. Penning, F. H. Schmidt	Phys. Rev. **105**, 647 (1957)	^{15}O, ^{19}Ne
[Pi85]	L. E. Piilonen	Ph.D. thesis, Princeton University	^{19}Ne
[Pl62]	H. S. Plendl *et al.*	Conf. Low Energy Nuclear Phys. Harwell (September 1962): AERE-R-4131, 22 (1962), abstr. 7a8	^{43}Ti
[Po59]	M. M. Povov *et al.*	Atomnaya Energiya 4, 196–298 (1958). English translations: Soviet J. At. Energy 4, 393–396 (1958) and J. Nucl. Energy 9, 190–193 (1959)	^{3}H

TABLE III. *(Continued.)*

Code	Authors	Reference	Measured nuclei
[Pr57]	I. D. Prokoshkin, A. A. Tiapkin	Zhur. Eksptl. I Teoret. Fiz. **32**, 117 (1957); Soviet Phys. JETP **5**, 148 (1957)	^{11}C
[Re99]	I. Reusen *et al.*	Phys. Rev. C **59**, 2416 (1999)	^{55}Ni
[Ri68]	A. I. M. Ritchie	Nucl. Instr. Methods **64**, 181 (1968)	^{13}N
[Ru77]	C. R. Rudy and K. C. Jordan	Progress Report MLM-2458, U.S. Department of Energy, Mound Laboratory, Miamisburg, Ohio, December 1977, pp. 2–10	^{3}H
[Sc48]	A. D. Schelberg *et al.*	Rev. Sci. Instr. **19**, 458 (1948)	^{43}Ti
[Sc58]	F. Schweizer	Phys. Rev. **110**, 1414 (1958)	^{37}K
[Sc70]	P. J. Scanlon, D. Crabtree	Can. J. Phys. **48**, 1578 (1970)	^{29}P, ^{33}Cl
[Se96]	D. R. Semon *et al.*	Phys. Rev. C **53**, 96 (1996)	^{57}Cu
[Sh89]	T. Shinozuka *et al.*	Proc. XXIII Yamada Conference on Nuclear Weak Process and Nuclear Structure, Osaka 1989, M. Morita, H. Ejiri, H. Ohtsubo, and T. Sato, eds. (World Scientific, Singapore, 1989), p. 108	^{57}Cu
[Sh93]	B. M. Sherrill *et al.*	Proc. 6th Int. Conf. on Nuclei far from Stability + 9th Conf. on Atomic Masses and Fundamental Constants, Germany 1992, R. Neugard and A. Wohr, eds., 891 (1993)	^{63}Ge
[Si87]	J. J. Simpson	Phys. Rev. C **35**, 752–754 (1987)	^{3}H
[Sm41]	J. H. C. Smith, D. B. Cowie	J. Appl. Phys. **12**, 78 (1941)	^{11}C
[Su62]	D. C. Sutton	Thesis, Princeton University (1962)	^{27}Si
[Ta73]	I. Tanihata *et al.*	J. Phys. Soc. Jpn. **34**, 848 (1973)	^{25}Al, ^{29}P, ^{33}Cl, ^{41}Sc
[Un00]	M. P. Unterweger and L. L. Lucas	Appl. Radiat. Isot. **52**, 527–531 (2000)	^{3}H
[Va63]	S. S. Vasilev, L. Y. Shavtvalov	Zhur. Eksperim. I Teor. Fiz. **45**, 1385 (1963), Soviet Phys. JETP **18**, 995 (1964)	^{43}Ti
[Va69]	S. S. Vasilev *et al.*	Vestn. Mosk. Univ., Fiz., Astron. No. 5, 3 (1969)	^{43}Ti
[Wa60]	R. Wallace, J. A. Welch, Jr.	Phys. Rev. **117**, 1297 (1960)	^{31}S
[We02]	L. Weissman *et al.*	Phys. Rev. C **65**, art. no. 044321	^{61}Ga
[Wi69]	G. L. Wick *et al.*	Nucl. Phys. **A138**, 209 (1969)	^{35}Ar
[Wi74]	D. H. Wilkinson, D. E. Alburger	Phys. Rev. C **10**, 1993 (1974)	^{19}Ne
[Wi80]	H. S. Wilson *et al.*	Phys. Rev. C **22**, 1696 (1980)	^{29}P, ^{31}S
[Wi93]	J. A. Winger *et al.*	Phys. Lett. **B299**, 214 (1993), Phys. Rev. C **48**, 3097 (1993)	^{61}Ga, ^{63}Ge, ^{65}As
[Wo02]	D. H. Woods *et al.*	App. Rad. Isot. **56**, 327 (2002)	^{11}C
[Wo69]	V. K. Wohlleben, E. Schuster	Radiochim. Acta **12**, 75 (1969)	^{17}F
[Yo65]	D. H. Youngblood *et al.*	Nucl. Phys. **65**, 602 (1965)	^{41}Sc

all the experimental errors were underestimated by the same factor. Finally, if $S > 1$ but the δx_i are of widely varying magnitudes, S is recalculated with only those results for which $\delta x_i \leqslant 3N^{1/2}\delta\bar{x}$ being retained; the recalculated scale factor is then applied in the usual way. In all three cases, no change is made to the original average $\bar{x}$ calculated with Eq. (24).

Adopted values for the half-life and the branching ratio are listed in Table VII, together with the calculated electron-capture fraction, P_{EC}, the deduced partial half-life,

TABLE IV. References to data used in the calculation of the various branching ratios.

Code	Authors	Reference	Nucleus
[Ac07]	N. Achouri and O. Naviliat-Cuncic	private communication	^{21}Na
[Ad81]	E. G. Adelberger *et al.*	Phys. Rev. C **24**, 313 (1981)	^{19}Ne
[Ad83]	E. G. Adelberger *et al.*	Phys. Rev. C **27**, 2833 (1983)	^{19}Ne
[Ad84]	E. G. Adelberger *et al.*	Nucl. Phys. **A417**, 269 (1984)	^{35}Ar
[Al74]	D. E. Alburger	Phys. Rev. C **9**, 991 (1974)	^{21}Na, ^{23}Mg, ^{31}S
[Al76]	D. E. Alburger	Phys. Rev. C **13**, 2593 (1976)	^{19}Ne
[Ar64]	S. E. Arnell, E. Wernbom	Arkiv Fysik **25**, 389 (1964)	^{17}F, ^{21}Na, ^{25}Al
[Ar84]	Y. Arai *et al.*	Nucl. Phys. **A420**, 193 (1984)	^{59}Zn
[Ay84]	J. Äystö *et al.*	Phys. Lett. **B138**, 369–372 (1984)	^{51}Fe
[Az77]	G. Azuelos *et al.*	Phys. Rev. C **15**, 1847 (1977)	^{21}Na, ^{23}Mg, ^{25}Al, ^{27}Si, ^{29}P, ^{31}S, ^{35}Ar, ^{37}K
[Be71]	D. Berenyi *et al.*	Nucl. Phys. **A178**, 76 (1971)	^{27}Si
[Bu85]	T. W. Burrows *et al.*	Phys. Rev. C **31**, 1490 (1985)	^{47}Cr
[De71]	C. Détraz *et al.*	Phys. Lett. **B34**, 128 (1971)	^{27}Si, ^{31}S, ^{35}Ar
[Ia06]	V. E. Iacob *et al.*	Phys. Rev. C **74**, 015501 (2006)	^{21}Na
[Ge71]	J. S. Geiger, B.W. Hooton	Can. J. Phys. **49**, 663 (1971)	^{35}Ar
[Go68a]	S. Gorodetzky *et al.*	Nucl. Phys. **A109**, 417 (1968)	^{23}Mg
[Ha80]	J. C. Hardy *et al.*	Phys. Lett. **B91**, 207 (1980)	^{49}Mn
[Ha94]	E. Hagberg *et al.*	Nucl. Phys. **A571**, 555 (1994)	^{39}Ca

TABLE IV. *(Continued.)*

Code	Authors	Reference	Nucleus
[Ha97]	E. Hagberg *et al.*	Phys. Rev. C **56**, 135 (1997)	^{37}K
[Ho50]	W. F. Hornyak *et al.*	Rev. Mod. Phys. **22**, 291 (1950), Phys. Rev. **77**, 160 (1950)	^{11}C
[Ho82]	P. Hornshoj *et al.*	Phys. Lett. **B116**, 4 (1982)	^{45}V
[Ho87]	J. Honkanen *et al.*	Nucl. Phys. **A471**, 489 (1987)	^{43}Ti
[Ho89]	J. Honkanen *et al.*	Nucl. Phys. **A496**, 462 (1989)	^{49}Mn, ^{51}Fe, ^{53}Co
[Lo62]	O. Lonsjo	Phys. Norvegica **1**, 41 (1962)	^{29}P
[Ma69]	L. Makela *et al.*	Bull. Am. Phys. Soc. **14**, 550 (1969)	^{25}Al
[Ma74]	F. M. Mann, R. W. Kavanagh	Nucl. Phys. **A235**, 299 (1974)	^{23}Mg, ^{27}Si
[Ma76]	F. M. Mann *et al.*	Nucl. Phys. **A258**, 341 (1976)	^{25}Al, ^{37}K
[Mo71]	C. E. Moss *et al.*	Nucl. Phys. **A170**, 111 (1971)	^{25}Al, ^{37}K
[Oi97]	M. Oinonen *et al.*	Phys. Rev. C **56**, 745 (1997)	^{71}Kr
[Sa93]	E. R. J. Saettler *et al.*	Phys. Rev. C **48**, 3069 (1993)	^{19}Ne
[Se96]	D. R. Semon *et al.*	Phys. Rev. C **53**, 96 (1996)	^{57}Cu
[Ta60]	W. L. Talbert, Jr. and M. G. Stewart	Phys. Rev. **119**, 272 (1960)	^{23}Mg, ^{25}Al, ^{27}Si, ^{31}S, ^{39}Ca
[Ti87]	D. R. Tilleya *et al.*	Nucl. Phys. **A474**, 1 (1987)	^{3}H
[We02]	L. Weissman *et al.*	Phys. Rev. C **65**, art. No. 044321	^{61}Ga
[Wi69]	G. L. Wick *et al.*	Nucl. Phys. **A138**, 209 (1969)	^{35}Ar
[Wi80]	H. S. Wilson *et al.*	Phys. Rev. C **22**, 1696 (1980)	^{21}Na, ^{25}Al, ^{29}P, ^{31}S, ^{33}Cl, ^{35}Ar, ^{41}Sc

TABLE V. References to data neglected in the calculation of the half-lives, $t_{1/2}$, of the mirror nuclei, with the reason for their rejection.

Code	Authors	Reference	Measured nuclei
Error bar 10 times higher than most precise measurement			
[Al57]	W. P. Alford, D. R. Hamilton	Phys. Rev. **105**, 673 (1957)	^{19}Ne
[Al59]	J. S. Allen *et al.*	Phys. Rev. **116**, 134 (1959)	^{19}Ne, ^{35}Ar
[Ar58]	S. E. Arnell *et al.*	Nucl. Phys. **6**, 196 (1958)	^{25}Al
[Ar81]	Y. Arai *et al.*	Phys. Lett. **B104**,186 (1981)	^{59}Zn
[Ba64]	J. E. E. Baglin, B. M. Spicer	Nucl. Phys. **54**, 549 (1964)	^{39}Ca
[Ba70]	T. T. Bardin *et al.*	Phys. Rev. C **2**, 2283 (1970)	^{33}Cl
[Bl51]	J. P. Blaser *et al.*	Helv. Phys. Acta **24**, 441 (1951)	^{27}Si
[Bl95]	B. Blank *et al.*	Phys. Lett. **B364**, 8 (1995)	^{75}Sr
[Bo53]	F. I. Boley	Iowa State Coll. J. Sci. **27**, 129 (1953)	^{21}Na, ^{23}Mg, ^{27}Si, ^{31}S, ^{33}Cl, ^{37}K, ^{39}Ca
[Br53]	R. Braams, C. L. Smith	Phys. Rev. **90**, 995 (1953)	^{39}Ca
[Bu65]	I. F. Bubb *et al.*	Nucl. Phys. **65**, 655 (1965)	^{27}Si
[Ch53]	J. L. W. Churchill *et al.*	Nature **172**, 460 (1953)	^{25}Al
[Cl58]	J. E. Cline, P. R. Chagnon	Bull. Am. Phys. Soc. 3, No. 3, 206, RA5 (1958)	^{27}Si
[Cr40]	E. C. Creutz *et al.*	Phys. Rev. **57**, 567 (1940)	^{21}Na, ^{27}Si
[Cr62]	J. G. Cramer, Jr., C. M. Class	Nucl. Phys. **34**, 580 (1962)	^{41}Sc
[Cs63]	J. Csikai, G. Peto	Phys. Lett. **4**, 252 (1963)	^{15}O
[El41]	D. R. Elliott, L. D. King	Phys. Rev. **60**, 489 (1941)	^{27}Si, ^{35}Ar, ^{41}Sc
[Es72]	M. A. Eswaran *et al.*	Phys. Rev. C **5**, 1270 (1972)	^{33}Cl
[Fr69]	J. M. Freeman *et al.*	Phys. Lett. B**5**, 296 (1969)	^{35}Ar
[Ge71]	J. S. Geiger, B. W. Hooton	Can. J. Phys. **49**, 663 (1971)	^{35}Ar
[Go64]	S. Gorodetzky *et al.*	Compt. Rend. Congr. Intern. Phys. Nucl., Paris, P. Gugenberger, ed., Centre National de la Recherche Scientifique, Paris, Vol. II, p. 408 (1964)	^{27}Si
[Gr71]	D. Grober, W. Gruhle	BMBW-FBK-71–09, p. 90 (1971)	^{25}Al, ^{29}P
[Ho73]	K. R. Hogstrom *et al.*	Nucl. Phys. **A215**, 598 (1973)	^{11}C
[Ho77]	P. Hornshoj *et al.*	Nucl. Phys. **A288**, 429 (1977)	^{47}Cr
[Ho81]	J. Honkanen *et al.*	Nucl. Phys. **A366**, 109 (1981)	^{59}Zn
[Hu41]	P. Huber	Helv. Phys. Acta **14**, 163 (1941)	^{31}S
[Hu43]	O. Huber *et al.*	Helv. Phys. Acta **16**, 33 (1943)	^{23}Mg (1,06 of 1,08)
[Hu44]	O. Huber *et al.*	Helv. Phys. Acta **17**, 195 (1944)	^{27}Si
[Hu54]	S. E. Hunt *et al.*	Phys. Rev. **95**, 611A (1954)	^{25}Al, ^{27}Si
[Ja60]	J. Janecke	Z. Naturforsch. **15**A, 593 (1960)	^{25}Al
[Ki01]	K. Kienle *et al.*	Prog. Part. Nucl. Phys. **46**, 73 (2001)	^{75}Sr, ^{79}Zr
[Ki56]	O. C. Kistner *et al.*	Phys. Rev. **104**, 154 (1956)	^{35}Ar
[La48]	R. V. Langmuir	Phys. Rev. **74**, 1559A (1948)	^{37}K
[Lo02]	M. J. Lopez-Jimenez *et al.*	Phys. Rev. C **66**, 025803 (2002)	^{53}Co, ^{55}Ni, ^{57}Cu, ^{59}Zn, ^{61}Ga, ^{63}Ge, ^{65}As, ^{67}Se, ^{71}Kr
[Mc49]	J. McElhinney *et al.*	Phys. Rev. **75**, 542 (1949)	^{31}S
[Mo71]	C. E. Moss *et al.*	Nucl. Phys. **A170**, 111 (1971)	^{25}Al, ^{37}K
[Na54]	M. E. Nahmias	J. Phys. Radium **15**, 677 (1954)	^{19}Ne

TABLE V. *(Continued.)*

Code	Authors	Reference	Measured nuclei
[Ne63]	J. W. Nelson *et al.*	Phys. Rev. **129**, 1723 (1963)	^{15}O, ^{31}S, ^{35}Ar
[Pa65]	J. R. Patterson *et al.*	Proc. Phys. Soc. (London) **86**, 1297 (1965)	^{11}C
[Ph53]	P. Phipps, D. J. Zaffarano	ISC-443 (1953)	^{21}Na
[Ri55]	C. S. Ring, Jr., D. J. Zaffarano	ISC-648 (1955)	^{39}Ca,
[Sc52]	G. Schrank, J. R. Richardson	Phys. Rev. **86**, 248–248 (1952)	^{19}Ne, ^{21}Na
[Sh84]	T. Shinozuka *et al.*	Phys. Rev. C **30**, 2111 (1984)	^{57}Cu
[Si44]	K. Siegbahn	Arkiv. Mat. Astron. Fysik **30**A, no. 20 (1944)	^{11}C
[Si73]	J. Singh	Proc. Nucl. Phys. and Solid State Phys. Symp., Chandigarh, Vol. 15B, p. 1 (1973)	^{11}C, ^{13}N
[So41]	A. K. Solomon	Phys. Rev. **60**, 279 (1941)	^{11}C
[Su53]	R. G. Summers-Gill *et al.*	Can. J. Phys. **31**, 70 (1953)	^{27}Si
[Su58]	C. R. Sun, B. T. Wright	Phys. Rev. **109**, 109 (1958)	^{37}K
[Ty54]	H. Tyren, P. A. Tove	Phys. Rev. **96**, 773 (1954)	^{43}Ti
[Va60]	S. S. Vasilev, L. Y. Shavtvalov	Zhur. Eksptl. I teoret. Fiz. **39**, 1221 (1960), Soviet Phys. JETP **12**, 851 (1961)	^{27}Si
[Va62]	S. S. Vasilev, L. Y. Shavtvalov	Izvest. Akad. Anuk SSSR, Ser. Fiz. **26**, 1495 (1962); Columbia Tech. Transl. **26**, 1521 (1963)	^{17}F, ^{33}Cl
[Wa60]	R. Wallace, J. A. Welch, Jr.	Phys. Rev. **117**, 1297 (1960)	^{21}Na, ^{23}Mg, ^{25}Al, ^{27}Si, ^{29}P, ^{33}Cl, ^{35}Ar, ^{37}K, ^{39}Ca, ^{41}Sc
[Wh39]	M. G. White *et al.*	Phys. Rev. **56**, 512–518 (1939)	^{19}Ne, ^{23}Mg
[Wh41]	M. G. White *et al.*	Phys. Rev. **59**, 63–68 (1941)	^{29}P, ^{31}S, ^{33}Cl, ^{35}Ar
No error bar quoted, and/or no definite value, merely a limit			
[Ho40]	J. B. Hoag	Phys. Rev. **57**, 937 (1940)	^{33}Cl
[Ma52]	W. M. Martin, S. W. Breckon	Can. J. Physics **30**, 64 (1952)	^{39}Ca
[Bl98]	B. Blank	J. Phys. G **24**, 1385 (1998)	^{77}Y
[Ki01]	K. Kienle *et al.*	Prog. Part. Nucl. Phys. **46**, 73 (2001)	^{81}Nb
Updated in [Re95]			
[Re95]	I. Reusen *et al.*	Proc. Intern. Conf. On exotic Nuclei and Atomic Masses, Arles 1995, 757	^{55}Ni
[Ve94]	L. Vermeeren *et al.*	Phys. Rev. Lett. **73**, 1935 (1994)	^{55}Ni
Pre-1958 data that are systematically higher than later and equally precise results			
[Ch53]	J. L. W. Churchill *et al.*	Nature **172**, 460 (1953)	^{13}N
[Da57]	H. Daniel, U. Schmidt-Rohr	Z. Naturforsch. **12**A, 750 (1957)	^{13}N
[De57]	A. S. Deineko *et al.*	Zhur. Eksptl. I Teoret. Fiz. **32**, 251 (1957); Soviet Phys. JETP **5**, 201 (1957)	^{13}N
[Ho50]	W. F. Hornyak *et al.*	Rev. Mod. Phys. **22**, 291 (1950), Phys. Rev. **77**, 160 (1950)	^{13}N
[No57]	E. Norbeck, Jr., C. S. Littlejohn	Phys. Rev. **108**, 754 (1957)	^{13}N
[Si45]	K. Siegbahn, Slaetis	Arkiv. Mat. Astron. Fysik **32**A, no. 9 (1945)	^{13}N
[Wa39]	Ward	Proc. Camb. Phil. Soc. **35**, 523 (1939)	^{13}N
[Wi55]	D. H. Wilkinson	Phys. Rev. **100**, 32 (1955)	^{13}N
Strongly deviating values, possible contamination			
[Ba55]	S. Bashkin *et al.*	Phys. Rev. **99**, 107 (1955)	^{15}O
[Br50]	H. Brown and V. Perez-Mendez	Phys. Rev. **78**, 649 (1950)	^{15}O
[Ki57]	O. C. Kistner *et al.*	Phys. Rev. **105**, 1339 (1957)	^{15}O
[Kl54]	R. M. Kline, D. J. Zaffarano	Phys. Rev. **96**, 1620 (1954)	^{15}O
Pre-1969 data that are systematically higher, possibility of ^{15}O contamination			
[Ar58]	S. E. Arnell *et al.*	Nucl. Phys. **6**, 196 (1958)	^{17}F
[Br49]	H. Brown and V. Perez-Mendez	Phys. Rev. **75**, 1286A (1949)	^{17}F
[Ja60]	J. Janecke	Z. Naturforsch. **15**A, 593 (1960)	^{17}F
[Ko54]	L. Koester	Z. Naturforsch. **9**A, 104 (1954)	^{17}F
[La51]	R. A. Laubenstein *et al.*	Phys. Rev. **84**, 12 (1951)	^{17}F
[Wo54]	C. Wong	Phys. Rev. **95**, 765–766 (1954)	^{17}F
Strongly deviating measurements			
[Ja60]	J. Janecke	Z. Naturforsch. **15**A, 593 (1960)	^{19}Ne
[Va64]	S. S. Vasilev *et al.*	Zhur. Eksperim. I Teor. Fiz. **47**, 1164 (1964), Soviet Phys. JETP **20**, 783 (1965)	^{19}Ne
[Wa60]	R. Wallace, J. A. Welch, Jr.	Phys. Rev. **117**, 1297 (1960)	^{19}Ne
[Mi58]	M. V. Mihailovic, B. Povh	Nuclear Phys. **7**, 296 (1958)	^{23}Mg
[Ro55]	H. Roderick *et al.*	Phys. Rev. **97**, 97–101 (1955)	^{29}P
[El41]	D. R. Elliott, L. D. King	Phys. Rev. **60**, 489 (1941)	^{31}S
[Mi58]	M. V. Mihailovic, B. Povh	Nucl. Phys. **7**, 296 (1958)	^{31}S
[El41]	D. R. Elliott, L. D. King	Phys. Rev. **60**, 489 (1941)	^{41}Sc
[Wa60]	R. Wallace, J. A. Welch, Jr.	Phys. Rev. **117**, 1297 (1960)	^{41}Sc
[Ho77]	P. Hornshoj *et al.*	Nucl. Phys. **A288**, 429 (1977)	^{51}Fe

TABLE VI. References to data that were not used in the calculation of the branching ratios with the reason for their rejection.

Code	Authors	Reference	Nucleus
No error bar quoted			
[St59]	R. S. Storey, K. G. McNeill	Can. J. Phys. **37**, 1072 (1959)	^{23}Mg
[Va60]	S. S. Vasilev, L. Y. Shavtvalov	Zhur. Eksptl. I teoret. Fiz. **39**, 1221 (1960), Soviet Phys. JETP **12**, 851 (1961)	^{27}Si
[Ma76]	F. M. Mann *et al.*	Nucl. Phys. **A258**, 341 (1976)	^{39}Ca
[En73]	P. M. Endt, C. van der Leun	Nucl. Phys. **A214**, 1 (1973)	^{43}Ti
[Ko73]	S. Kochan *et al.*	Nucl. Phys. **A204**, 185 (1973)	^{53}Co
[Ho77]	P. Hornshoj *et al.*	Nucl. Phys. **A288**, 429 (1977)	^{55}Ni
[Ay84]	J. Äystö *et al.*	Phys. Lett. **B138**, 369–372 (1984)	^{55}Ni
[Ar81]	Y. Arai *et al.*	Phys. Lett. **B104**, 186 (1981)	^{59}Zn
[Wi93]	J. A. Winger *et al.*	Phys. Lett. **B299**, 214 (1993), Phys. Rev. C **48**, 3097 (1993)	^{63}Ge, ^{65}As
[Ba94]	P. Baumann *et al.*	Phys. Rev. C **50**, 1180 (1994)	^{67}Se
[Bl95]	B. Blank *et al.*	Phys. Lett. **B364**, 8 (1995)	^{67}Se, ^{71}Kr
[Ew81]	G. T. Ewan *et al.*	Nucl. Phys. **A352**, 13 (1981)	^{71}Kr
Error bar 10 times higher than most precise measurement			
[Ro55]	H. Roderick *et al.*	Phys. Rev. **97**, 97–101 (1955)	^{29}P
[Ki56]	O. C. Kistner *et al.*	Phys. Rev. **104**, 154 (1956)	^{35}Ar
[Ad84]	E. G. Adelberger *et al.*	Nucl. Phys. **A417**, 269 (1984)	^{39}Ca
[Oi99]	M. Oinonen *et al.*	Eur. Phys. J. A **5**, 151 (1999)	^{61}Ga
No branching ratio is given, only a (lower) limit			
[Ki58]	O. C. Kistner, B. M. Rustad	Phys. Rev. **112**, 1972 (1958)	^{39}Ca
[De71]	C. Détraz *et al.*	Phys. Lett. **B34**, 128 (1971)	^{39}Ca
[Az77]	G. Azuelos *et al.*	Phys. Rev. C **15**, 1847 (1977)	^{39}Ca
[Ho77]	P. Hornshoj *et al.*	Nucl. Phys. **A288**, 429 (1977)	^{47}Cr, ^{51}Fe
β^+ contamination from ^{21}F according to [Al74]			
[Ta60]	W. L. Talbert, Jr. and M. G. Stewart	Phys. Rev. **119**, 272 (1960)	^{21}Na
[Ar64]	S. E. Arnell, E. Wernbom	Arkiv Fysik **25**, 389 (1964)	^{21}Na
Only one important level in daughter was used although there are more			
[Sh84]	T. Shinozuka *et al.*	Phys. Rev. C **30**, 2111 (1984)	^{57}Cu

t [cf. Eq. (6)], and the Q_{EC} value from Ref. [17]. The P_{EC} values were obtained from the tables of Bambynek *et al.* [35] and Firestone [36]. No errors were assigned to these P_{EC} values as they are expected to be accurate to a few parts in 100 [18,35] such that they do not contribute perceptibly to the overall uncertainties.

TABLE VII. Overview of the adopted values for the half-lives, $t_{1/2}$, and the branching ratios, BR, for the $T = 1/2$ mirror β transitions, together with the electron capture probabilities, P_{EC} (from Refs. [35,36]), the deduced partial half-lives, t [cf. Eq. (6)], and the Q_{EC} values (from Ref. [17]).

Parent nucleus	$t_{1/2}$ (s)	P_{EC} (%)	BR (%)	t (s)	Q_{EC} (keV)
^{3}H	$(38854 \pm 35) \times 10^4$	N/A	100	$(38854 \pm 35) \times 10^4$	18.5912 ± 0.0010
^{11}C	1221.6 ± 1.5	0.231	100	1224.4 ± 1.5	1982.40 ± 0.90
^{13}N	597.88 ± 0.23	0.196	100	599.05 ± 0.23	2220.47 ± 0.27
^{15}O	122.24 ± 0.27	0.100	100	122.37 ± 0.27	2754.16 ± 0.50
^{17}F	64.61 ± 0.17	0.147	100	64.70 ± 0.17	2760.51 ± 0.27
^{19}Ne	17.248 ± 0.029	0.101	99.9858 ± 0.0020	17.268 ± 0.029	3238.83 ± 0.30
^{21}Na	22.487 ± 0.054	0.094	95.235 ± 0.069	23.634 ± 0.060	3547.58 ± 0.70
^{23}Mg	11.3243 ± 0.0098	0.073	91.78 ± 0.26	12.348 ± 0.037	4056.1 ± 1.3
^{25}Al	7.182 ± 0.012	0.079	99.151 ± 0.031	7.250 ± 0.012	4276.63 ± 0.50
^{27}Si	4.135 ± 0.019	0.065	99.818 ± 0.022	4.145 ± 0.020	4812.36 ± 0.10
^{29}P	4.140 ± 0.016	0.075	98.290 ± 0.030	4.215 ± 0.016	4942.45 ± 0.60
^{31}S	2.574 ± 0.017	0.069	98.837 ± 0.031	2.606 ± 0.017	5396.3 ± 1.5
^{33}Cl	2.5111 ± 0.0040	0.075	98.45 ± 0.14	2.5526 ± 0.0055	5582.59 ± 0.40
^{35}Ar	1.7752 ± 0.0010	0.073	98.358 ± 0.066	1.8062 ± 0.0016	5966.14 ± 0.70
^{37}K	1.2248 ± 0.0073	0.080	97.99 ± 0.14	1.2510 ± 0.0077	6147.46 ± 0.20
^{39}Ca	0.8609 ± 0.0028	0.078	99.9975 ± 0.0002	0.8616 ± 0.0028	6532.61 ± 1.9
^{41}Sc	0.5962 ± 0.0022	0.096	99.963 ± 0.003	0.5970 ± 0.0022	6495.37 ± 0.16
^{43}Ti	0.5222 ± 0.0057	0.094	90.2 ± 0.8	0.5795 ± 0.0082	6866.9 ± 7.3
^{45}V	0.5465 ± 0.0051	0.098	95.7 ± 1.5	0.572 ± 0.010	7126 ± 17

TABLE VIII. Calculated quantities and corrections needed to obtain the $\mathcal{F}t^{\text{mirror}}$ values [Eq. (23)]. Details are given in the text.

Parent nucleus	f_V	$f_V t$ (s)	$\frac{f_A}{f_V}$	δ_1 (%)	δ_2 (%)	δ_3 (%)	δ_{α^2} (%)	δ'_R (%)	δ^V_{c1} (%)	δ^V_{c2} (%)	δ^V_{NS} (%)	$\delta^V_C - \delta^V_{\text{NS}}$ (%)
^{3}H	$(2.8757 \pm 0.0026) \times 10^{-6}$	1117.3(14)	1.00492	1.816	−0.084	0.001	0.035	1.768(1)	0.002(2)	0.025(1)	−0.13(2)	0.16(2)
^{11}C	3.193 ± 0.012	3910(16)	1.01052	1.450	0.179	0.004	0.027	1.660(4)	0.003(3)	0.925(20)	−0.12(2)	1.04(3)
^{13}N	7.716 ± 0.007	4622.0(47)	1.00450	1.396	0.208	0.006	0.025	1.635(6)	0.006(6)	0.265(15)	−0.06(2)	0.33(3)
^{15}O	35.500 ± 0.044	4344(11)	1.00263	1.298	0.225	0.008	0.024	1.555(8)	0.016(10)	0.165(15)	−0.04(2)	0.22(3)
^{17}F	35.217 ± 0.024	2278.6(61)	1.01704	1.297	0.257	0.010	0.023	1.587(10)	0.025(10)	0.560(25)	−0.04(2)	0.62(3)
^{19}Ne	98.532 ± 0.058	1701.4(30)	1.01428	1.226	0.272	0.012	0.022	1.533(12)	0.140(30)	0.275(25)	−0.11(2)	0.52(4)
^{21}Na	170.97 ± 0.21	4041(11)	1.01801	1.186	0.291	0.015	0.021	1.514(15)	0.028(10)	0.320(25)	−0.06(2)	0.41(3)
^{23}Mg	378.59 ± 0.73	4675(17)	1.01935	1.129	0.309	0.017	0.020	1.476(17)	0.023(10)	0.270(20)	−0.11(2)	0.40(3)
^{25}Al	508.45 ± 0.35	3686.1(67)	1.02373	1.108	0.328	0.020	0.020	1.475(20)	0.061(40)	0.400(25)	−0.06(2)	0.52(5)
^{27}Si	993.61 ± 0.12	4119(19)	1.02697	1.059	0.342	0.023	0.019	1.443(23)	0.052(30)	0.260(15)	−0.11(2)	0.42(4)
^{29}P	1136.7 ± 0.8	4791(18)	1.02231	1.047	0.361	0.026	0.020	1.453(26)	0.091(40)	0.885(35)	−0.09(2)	1.07(6)
^{31}S	1841.5 ± 2.9	4798(33)	1.01951	1.011	0.372	0.029	0.018	1.430(29)	0.220(30)	0.495(20)	−0.08(2)	0.79(4)
^{33}Cl	2190.0 ± 0.9	5590(12)	0.98777	0.996	0.389	0.032	0.018	1.435(32)	0.145(20)	0.720(55)	−0.06(2)	0.93(6)
^{35}Ar	3121.9 ± 2.1	5638.8(63)	0.98938	0.969	0.399	0.035	0.017	1.421(35)	0.038(10)	0.455(45)	−0.04(2)	0.53(5)
^{37}K	3623.9 ± 0.7	4533(28)	1.00456	0.958	0.417	0.039	0.017	1.431(39)	0.054(10)	0.680(60)	−0.06(2)	0.79(6)
^{39}Ca	4985.8 ± 8.0	4296(16)	1.00101	0.934	0.428	0.042	0.017	1.421(42)	0.330(60)	0.525(55)	−0.09(2)	0.95(8)
^{41}Sc	4745.0 ± 0.6	2833(11)	1.03671	0.941	0.449	0.047	0.017	1.453(47)	0.041(20)	0.780(60)	−0.04(2)	0.86(7)
^{43}Ti	6336 ± 37	3671(56)	1.03184	0.918	0.459	0.050	0.016	1.444(50)	0.170(100)	0.330(30)	−0.13(2)	0.63(11)
^{45}V	7628 ± 100	4361(98)	1.04112	0.903	0.466	0.054	0.016	1.439(54)	0.170(100)	0.695(70)	−0.06(2)	0.93(12)

IV. THE $\mathcal{F}t^{\text{mirror}}$ VALUES

Having surveyed the experimental data we can now turn to the determination of the ft values. The statistical rate function, f, for each transition was calculated using the procedure and the code described in Ref. [18]. Results appear in column 2 of Table VIII. To obtain $\mathcal{F}t^{\text{mirror}}$ values according to Eq. (23) we must still deal with the small correction terms. The values for the nucleus dependent radiative correction $\delta'_R = \delta_1 + \delta_2 + \delta_3 + \delta_{\alpha^2}$ are listed in columns 5–9 of Table VIII. Similar to the superallowed Fermi β decays we have assigned an uncertainty equal to the δ_3 term as an estimate of the error made in stopping the calculations at the order $Z^2\alpha^3$. Finally, one still has to deal with the nuclear-structure-dependent corrections $\delta^V_C = \delta^V_{C1} + \delta^V_{C2}$ and δ^V_{NS}. Two of these corrections, δ^V_{NS} and δ^V_{C1}, are very sensitive to the details of the shell-model calculation used in their evaluation. Fortunately, these two terms are also the smallest of the corrections we need in Eq. (23). We have mounted shell-model calculations using standard effective interactions and modest-size model spaces to evaluate them following exactly the same procedures as discussed in Ref. [33]. Further, we assigned a generous error to account for their inherent model dependence. Less dependent on nuclear structure is the larger radial overlap correction, δ_{c2}. Here we are guided by the recent work of Towner and Hardy [25], who pointed out the importance of including "core" orbitals in the shell-model evaluation of spectroscopic amplitudes. A decision has to be made as to which core orbitals should be included in the active model space. Towner and Hardy's criterion is that experimental neutron pickup reactions should observe strong spectroscopic factors for the orbitals in question. We have followed this criterion in obtaining our values for δ_{c2}. All these corrections are listed in columns 10–12 in Table VIII with their sum in column 13. In total, these nuclear-structure-dependent corrections are of order 1% or less.

One other quantity that depends weakly on a shell-model calculation is the ratio f_A/f_V (column 4 in Table VIII). Here a modest shell-model calculation is sufficient. We can also use these shell-model calculations to determine the relative sign of the Fermi and Gamow-Teller matrix elements, which can then be taken as the sign of ρ in Eq. (22). Finally, the resulting $\mathcal{F}t^{\text{mirror}}$ values and corresponding values for ρ (using $\mathcal{F}t^{0^+\to 0^+} = (3071.4 \pm 0.8)$ s [25], and assigning an error of 20% to the calculated deviations of f_A/f_V from unity) are recorded in Table IX. As can be seen, for most of the nineteen

TABLE IX. The $\mathcal{F}t^{\text{mirror}}$ values and Gamow-Teller/Fermi mixing ratios, ρ (assuming $C_A = -1.27\ C_V$), with their relative uncertainties.

Parent nucleus	$\mathcal{F}t$ (s)	$\delta\mathcal{F}t$ (%)	ρ	$\delta\rho$ (%)
^{3}H	1135.3 ± 1.5	0.13	−2.0951 ± 0.0020	0.10
^{11}C	3933 ± 16	0.41	0.7456 ± 0.0043	0.58
^{13}N	4682.0 ± 4.9	0.10	0.5573 ± 0.0013	0.23
^{15}O	4402 ± 11	0.25	−0.6281 ± 0.0028	0.45
^{17}F	2300.4 ± 6.2	0.27	−1.2815 ± 0.0035	0.27
^{19}Ne	1718.4 ± 3.2	0.19	1.5933 ± 0.0030	0.19
^{21}Na	4085 ± 12	0.29	−0.7034 ± 0.0032	0.45
^{23}Mg	4725 ± 17	0.36	0.5426 ± 0.0044	0.81
^{25}Al	3721.1 ± 7.0	0.19	−0.7973 ± 0.0027	0.34
^{27}Si	4160 ± 20	0.48	0.6812 ± 0.0053	0.78
^{29}P	4809 ± 19	0.40	−0.5209 ± 0.0048	0.92
^{31}S	4828 ± 33	0.68	0.5167 ± 0.0084	1.63
^{33}Cl	5618 ± 13	0.23	0.3076 ± 0.0042	1.37
^{35}Ar	5688.6 ± 7.2	0.13	−0.2841 ± 0.0025	0.88
^{37}K	4562 ± 28	0.61	0.5874 ± 0.0071	1.21
^{39}Ca	4315 ± 16	0.37	−0.6504 ± 0.0041	0.63
^{41}Sc	2849 ± 11	0.39	−1.0561 ± 0.0053	0.50
^{43}Ti	3701 ± 56	1.51	0.800 ± 0.016	2.00
^{45}V	4382 ± 99	2.26	−0.621 ± 0.025	4.03

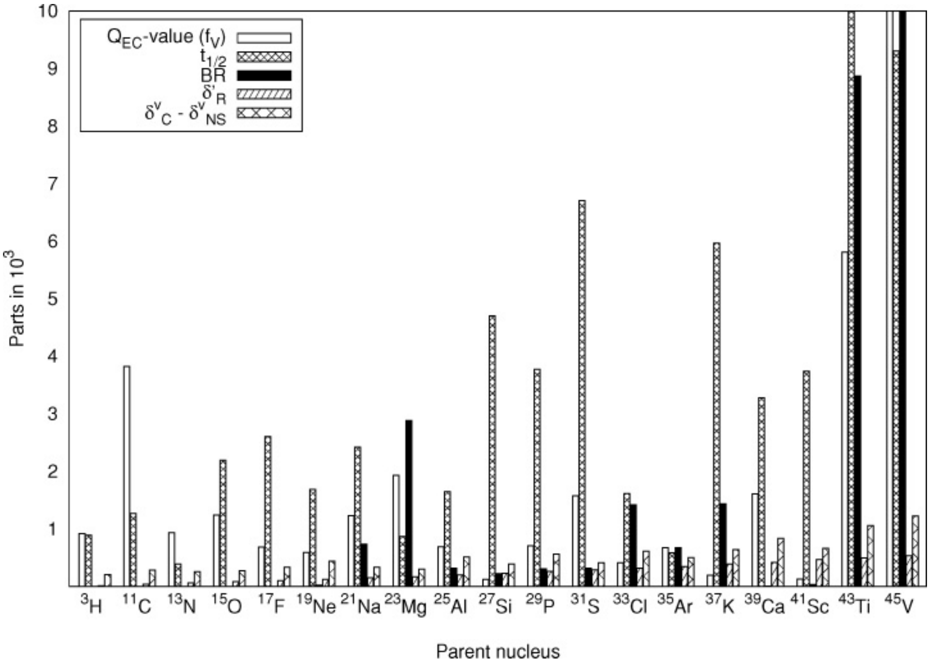

FIG. 1. Histogram of the fractional uncertainties attributed to each experimental and theoretical input factor that contributes to the final $\mathcal{F}t^{\text{mirror}}$ values.

transitions the precision on the $\mathcal{F}t^{\text{mirror}}$ value is better than 1%, except for ^{43}Ti and ^{45}V, whereas it is even better than 0.3% in nine cases. The highest precision is reached for ^{3}H, ^{13}N, and ^{35}Ar.

In Fig. 1 the fractional uncertainties attributed to each experimental and theoretical input factor that contributes to the final $\mathcal{F}t^{\text{mirror}}$ value are shown in the form of a histogram for all 19 transitions. Clearly, to bring all contributions at the level of 1 part in 1000 or better, new and more precise measurements of the half-lives, $t_{1/2}$, are required for almost all transitions. Better Q_{EC} values are needed for almost half of the transitions, i.e., ^{11}C, ^{15}O, ^{21}Na, ^{23}Mg, ^{31}S, ^{39}Ca, ^{43}Ti, and ^{45}V, whereas more precise measurements of the branching ratio, BR, are needed for ^{23}Mg, ^{33}Cl, ^{37}K, ^{43}Ti, and ^{45}V. The theoretical corrections, δ_R and $\delta_C - \delta_{\text{NS}}$ contribute less than 1 part in 1000 to the final $\mathcal{F}t^{\text{mirror}}$ values in all cases except ^{43}Ti and ^{45}V.

V. STANDARD MODEL VALUES FOR THE β-DECAY CORRELATION COEFICIENTS

With these values for ρ we can now calculate the standard model values for correlation coefficients in β decay [19] that are of interest to search for physics beyond the standard

TABLE X. Calculated standard model values for the a, A, B, N, and R correlation coefficients for the $T = 1/2$ mirror β transitions up to ^{45}V, using the mixing ratios listed in Table IX. The D triple correlation is zero in the standard model. The β particle longitudinal polarization, G, is -1 for β^- decay and $+1$ for β^+ decay. The N and R correlations are nonzero due to final-state interactions (FSI). Note that the about 10% accuracy to which the Eqs. (32) and (33) used to calculate N^{FSI} and R^{FSI} are valid [41] is not included in the error bars.

Parent nucleus	spin J	a_{SM}	δa (%)	A_{SM}	δA (%)	B_{SM}	δB (%)	R^{FSI}	N^{FSI}
^{3}H	1/2	-0.08593 ± 0.00038	0.44	-0.09408 ± 0.00046	0.49	0.991849 ± 0.000076	0.01	0.005045 ± 0.000025	0.09077 ± 0.00044
^{11}C	3/2	0.5236 ± 0.0035	0.67	-0.59946 ± 0.00016	0.03	-0.8853 ± 0.0023	0.26	-0.008100 ± 0.000006	-0.20804 ± 0.00012
^{13}N	1/2	0.6840 ± 0.0011	0.16	-0.333028 ± 0.000040	0.01	-0.6490 ± 0.0012	0.18	-0.004568 ± 0.000001	-0.099454 ± 0.000022
^{15}O	1/2	0.6228 ± 0.0024	0.39	0.7087 ± 0.0022	0.31	0.33148 ± 0.00020	0.06	0.008470 ± 0.000027	0.16124 ± 0.00051
^{17}F	5/2	0.1713 ± 0.0017	0.99	0.99739 ± 0.00018	0.02	0.64222 ± 0.00092	0.14	0.013582 ± 0.000003	0.226180 ± 0.000049
^{19}Ne	1/2	0.0435 ± 0.0010	2.30	-0.04166 ± 0.00095	2.28	-0.998186 ± 0.000085	0.01	-0.000522 ± 0.000012	-0.00779 ± 0.00018
^{21}Na	3/2	0.5587 ± 0.0027	0.48	0.8614 ± 0.0019	0.22	0.59661 ± 0.00032	0.05	0.010731 ± 0.000024	0.14457 ± 0.00033
^{23}Mg	3/2	0.6967 ± 0.0044	0.63	-0.5584 ± 0.0017	0.30	-0.7404 ± 0.0040	0.54	-0.006529 ± 0.000020	-0.08023 ± 0.00025
^{25}Al	5/2	0.4818 ± 0.0021	0.44	0.9350 ± 0.0011	0.12	0.71289 ± 0.00016	0.02	0.011214 ± 0.000013	0.12639 ± 0.00014
^{27}Si	5/2	0.5774 ± 0.0053	0.92	-0.6959 ± 0.0013	0.19	-0.8771 ± 0.0032	0.36	-0.007899 ± 0.000015	-0.08230 ± 0.00015
^{29}P	1/2	0.7154 ± 0.0048	0.67	0.6154 ± 0.0046	0.75	0.33083 ± 0.00044	0.13	0.007298 ± 0.000054	0.07059 ± 0.00053
^{31}S	1/2	0.7190 ± 0.0084	1.17	-0.33043 ± 0.00083	0.25	-0.6114 ± 0.0080	1.31	-0.003804 ± 0.000010	-0.034356 ± 0.000087
^{33}Cl	3/2	0.8848 ± 0.0029	0.33	-0.4007 ± 0.0040	1.00	-0.4699 ± 0.0057	1.21	-0.004739 ± 0.000048	-0.04010 ± 0.00040
^{35}Ar	3/2	0.9004 ± 0.0016	0.18	0.4371 ± 0.0036	0.82	0.3773 ± 0.0026	0.69	0.005102 ± 0.000041	0.04063 ± 0.00033
^{37}K	3/2	0.6580 ± 0.0061	0.93	-0.5739 ± 0.0021	0.37	-0.7791 ± 0.0058	0.74	-0.006863 ± 0.000025	-0.05158 ± 0.00019
^{39}Ca	3/2	0.6036 ± 0.0041	0.68	0.8270 ± 0.0029	0.35	0.58916 ± 0.00076	0.13	0.009766 ± 0.000034	0.06950 ± 0.00024
^{41}Sc	7/2	0.2970 ± 0.0033	1.11	0.99777 ± 0.00032	0.03	0.76344 ± 0.00080	0.10	0.012480 ± 0.000004	0.084287 ± 0.000027
^{43}Ti	7/2	0.480 ± 0.016	3.33	-0.7737 ± 0.0016	0.21	-0.9470 ± 0.0057	0.60	-0.009563 ± 0.000023	-0.06147 ± 0.00014
^{45}V	7/2	0.629 ± 0.021	3.34	0.852 ± 0.017	2.00	0.729 ± 0.010	1.37	0.01060 ± 0.00022	0.0650 ± 0.0013

electroweak model (e.g., Refs. [37–40]). The standard model assumes only vector and axial-vector interactions with maximal parity violation. In addition, it is expected that the effects due to CP (or T) violation are negligible in the light quark sector at the present level of precision. These assumptions result in the conditions $C'_V = C_V$, $C'_A = C_A$, $C_S = C'_S = C_T = C'_T = 0$, and $Im(C'_i) = Im(C_i) = 0$ for $i = V, A$. Neglecting Coulomb as well as induced recoil effects one then obtains (the upper sign is for β^- decay and the lower sign for β^+ decay), for the β-neutrino angular correlation coefficient

$$a_{\mathrm{SM}} = \frac{1 - \rho^2/3}{1 + \rho^2}, \tag{27}$$

for the β asymmetry parameter

$$A_{\mathrm{SM}} = \frac{\mp\lambda_{J'J}\rho^2 - 2\delta_{J'J}\sqrt{\frac{J}{J+1}}\rho}{1 + \rho^2}, \tag{28}$$

for the neutrino asymmetry parameter

$$B_{\mathrm{SM}} = \frac{\pm\lambda_{J'J}\rho^2 - 2\delta_{J'J}\sqrt{\frac{J}{J+1}}\rho}{1 + \rho^2}, \tag{29}$$

and for the β-particle longitudinal polarization

$$G_{\mathrm{SM}} = \mp 1, \tag{30}$$

where $\delta_{J'J}$ is the Kronecker δ and

$$\lambda_{J'J} = \frac{1}{J + 1} \tag{31}$$

for the $J \to J' = J$ mirror β transitions.

Note that the coefficients $b_{\mathrm{SM}} = D_{\mathrm{SM}} = 0$ in the standard model. When including also the effect of the Coulomb interaction of the charged nucleus and emitted β particle (i.e., final-state interaction, FSI) it turns out that, to first order in α, this depends for the a, b, A, B, D, and G correlation coefficients on interferences between the standard model V, A coupling constants and the non–standard model S, T coupling constants [19], and therefore vanishes in the standard model. For the N and R correlation coefficients, however, the final state effects contain terms that depend on the time reversal invariant parts of the vector and/or axial-vector coupling constants and are thus nonzero in the standard model. To first order in αZ one has [19]

$$N_{\mathrm{SM}}^{\mathrm{FSI}} = \mp\frac{\gamma m_e}{E_e} A_{\mathrm{SM}} \tag{32}$$

and

$$R_{\mathrm{SM}}^{\mathrm{FSI}} = \mp\frac{\alpha Z m_e}{p} A_{\mathrm{SM}} \tag{33}$$

with E_e the total electron energy. Numerical calculations [41] have shown that the values obtained for N_{FSI} and R_{FSI} within the used approximation are accurate at the 10% level.

The standard model values for the coefficients a, A, and B as well as the values for N_{FSI} and R_{FSI} at the β spectrum endpoint, all calculated with the values for ρ obtained from our ft value analysis, are listed in Table X. A full analysis of the sensitivity of the different correlation coefficients to several types of physics beyond the standard model as well as the effect of recoil order corrections (i.e., weak magnetism) on the correlation coefficients is in preparation and will be published elsewhere [42].

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