Survey of world data for the superallowed decays of ^{42}Ti, ^{46}Cr, ^{50}Fe, and ^{54}Ni

J.C. Hardy and I.S. Towner

At regular intervals over more than four decades, we have published critical surveys of world data on superallowed $0^+ \rightarrow 0^+$ Fermi β transitions and their impact on weak-interaction physics, with the last survey appearing in February 2015 [1]. In all, 20 transitions were included in this most-recent survey, of which 18 had a complete set of data, comprising in each case the Q_{EC} value, half-life and branching ratio. Of those 18, all but 4 had been measured to high precision. Our justification for including 20 cases, some of which were incomplete or poorly known was that we deemed these 20 cases to encompass all those that were likely to be accessible to precision measurements in the near future.

By the time the survey was published, our prediction had already been proven wrong: In January 2015, Molina *et al.* [2] reported a measurement of the half-lives and Gamow-Teller branching ratios for the β decays of ^{42}Ti, ^{46}Cr, ^{50}Fe and ^{54}Ni. Although the ^{42}Ti transition was included in our survey, those of ^{46}Cr, ^{50}Fe and ^{54}Ni were not. In fact, the Q_{EC} values for the three latter transitions are still poorly known and even the new measurements of the half-lives and branching ratios have yet to reach the precision required to contribute meaningfully to any standard-model tests. Nevertheless, Molina *et al.* have convincingly demonstrated that these nuclei are indeed accessible and potentially amenable to more precise measurements.

As a result, we produced and published [3] an addendum to our 2015 survey, in which we extended the same evaluation of world data to the three new superallowed transitions and we also evaluated the correction terms required to understand the results, taking the opportunity to update results for ^{42}Ti to incorporate new information. The correction-term calculations are described elsewhere in this report [4]. Here we focus on the survey of world data.

We surveyed world data using exactly the same methods as in our 2015 survey [1] and, for consistency, we displayed the results in a similar tabular format even though relatively few references are involved. For details of the measured results and the publications in which they appeared the reader is referred to Ref. [3]. In Table I, we present the average world-data results together with the corrected $\mathcal{F}t$ values derived using the calculated correction terms [4].

Table I. World data average results for the decays of ^{42}Ti, ^{46}Cr, ^{50}Fe, and ^{54}Ni.

Parent nucleus	f	Partial half-life t (ms)	ft (s)	$\mathcal{F}t$
^{42}Ti	7130.5±1.4	433 ± 12	3090 ± 88	3096 ± 88
^{46}Cr	10660±150	292.6 ± 9.1	3120 ± 110	3130 ± 110
^{50}Fe	14950±600	204.8 ± 4.5	3060 ± 140	3080 ± 140
^{54}Ni	21850±670	144.9 ± 2.3	3170 ± 110	3180 ± 110

Since the comparison of mirror pairs of $0^+ \rightarrow 0^+$ transitions has been shown [5] to be a valuable method for testing the isospin-symmetry-breaking corrections, we also tabulated the predicted *ft*-value ratios for the four mirror pairs, of which ^{42}Ti, ^{46}Cr, ^{50}Fe and ^{54}Ni are the most neutron deficient parents. These predicted ratios, presented here in Table 2, provide ample motivation for future high-precision measurements.

Table II. Calculated ratios ft^a/ft^b for four mirror doublets.

Decay pairs *a;b*	$\delta_R^{\,b}$ - $\delta_R^{\,a}$ (%)	$\delta_C^{\,b}$ - $\delta_C^{\,a}$ (%)	ft^a/ft^b
^{42}Ti → ^{42}Sc; ^{42}Sc → ^{42}Ca	0.296 (30)	-0.265 (25)	1.00564 (39)
^{46}Cr → ^{46}V; ^{46}V → ^{46}Ti	0.165 (10)	-0.140 (82)	1.00305 (83)
^{50}Fe → ^{50}Mn; ^{50}Mn → ^{50}Cr	0.120 (20)	0.005 (43)	1.00115 (47)
^{54}Ni → ^{54}Co; ^{54}Co → ^{54}Fe	0.143 (30)	-0.020 (85)	1.00163 (90)

With future experimental precision at the ~0.1 % level, it would become possible to test the corrections for these pairs in the way we first demonstrated in Park *et al*. [5] for the mirror superallowed decays of ^{38}Ca and ^{38m}K. Particularly attractive is the mass-42 mirror pair, for which the *ft*-value ratio is expected to differ from unity by nearly 0.6%.

[1] J.C. Hardy and I.S. Towner, Phys. Rev. C **91**, 025501 (2015).

[2] F. Molina *et al.,* Phys. Rev. C **91**, 014301 (2015).

[3] I.S. Towner and J.C. Hardy, Phys. Rev. C **92**, 055505 (2015).

[4] I.S. Towner and J.C. Hardy, *Progress in Research,* Cyclotron Institute, Texas A&M University (2015-2016) p. III-22.

[5] H.I. Park *et al.,* Phys. Rev. Lett. **112**, 102502 (2014) and Phys. Rev. C **92**, 015502 (2015).