F. t. VALUES FOR SUPERALLOWED BETA DECAYS

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SUMMARY: Recent experimental studies have improved the significance of the f.t values of superallowed O^+ -> O^+ nuclear β-decays. In this work, a survey was made of some properties; half-lives, branching ratio, f values, for superallowed β-decay branches. These data were used to calculate the resulting corrected F. t values for each transitions. The result of F.t for C^{10}, O^{14}, Mg^{22}, Al^{26m}, CI^{34}, Sc^{12}, V^{46}, Mn^{50}, Co^{54} were compared with those of the other studies. The average F.t value for all 9 transitions is 3080, 9 ± 0,73 sn.

Key Words: Beta decays.

INTRODUCTION

It is possible to test the Conserved Vector Current (CEC) hypothesis by extracting the value of the effective weak vector Coupling Constant (G'_V) from the experimental f.t values for 0^+ -> 0^+ superallowed β-decays. However, it is firstly essential to consider all relevant experimental data and incorporate changes and improvements in half-lives, matrix elements, Fermi functions. e.c. In this work the corrected F.t values were calculated by giving a survey with updated measurements on the nine best-known superallowed emitters: C^{10}, O^{14}, Mg^{22}, Al^{26m}, CI^{34}, Sc^{42}. V^{46}, Mn^{50}, Co^{54}.

The connection among the half-lives, nuclear matrix element and the vector coupling constant for superallowed β-decay is given by,

$$\text{f.t}\,(1+\delta R) = \frac{K}{G_v^2 \, |Mv|^2} \qquad (1)$$

$$|Mv|^2 = 2\,(1-\delta c)\,;\; G_v^2 = G_v^2 (1+\Delta_R)$$

$$K = \frac{2\pi^3\,(1n2)h^7 C^6}{(mc^2)^5}$$

$$= (1{,}23062 \pm 0{,}00003)\text{x}10^{-94}\ \text{erg}^2.\text{cm}^6.\text{sn.}$$

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The constant K was taken from ref. (1) Here f is the statistical rate function, t the partial half-live for the transition, G'_V is the effective vector coupling constant and M_v is the Fermi matrix element. δR and ΔR are the Radiative corrections terms. δR varies from nucleus to nucleus and ΔR is a constant. Radiative corrections arise from the interaction of the decaying nucleon and the emitted positron with the external electromagnetic field. δc modifies the fermi matrix element as a result of Coulomb and nuclear charge-dependent force.

To extract the polar vector beta-decay coupling constant, G'_V and to test CVC hypothesis accurate values of the F.t must be known. The corrected ft value, F.t, :

$$\text{F.t} = \text{f.t}\,(1 + \delta_R)\,(1- \delta_c) \qquad (2)$$

and

$$\text{F.t} = \frac{K}{2\,G_v^2 (1+\Delta_R)}$$

F.t values must be constant for superallowed nuclear β-transitions.

Our purpose will be to examine all relevant experimental data (after 1970) on nine best - known transitions and

Table 1a : Half-Lives of Superollowed β-emitters

	Measured Half-Lives, t 1/2 (msn)	Average Value
C^{10}	19280 ± 20 (4) 19151 ± 26 (5)	19228,4 ± 16
O^{14}	71056 ± 36 (6) 70613 ± 25 (9) 70480 ± 77 (7) 70588 ± 28 (10) 70680 ± 77 (8) 70320 ± 120 (11) 70480 ± 180 (4)	70687 ± 16
Mg^{22}	3970 ± 90 (12) 3857 ± 9 (1) (13)	3859 ± 9,01
Al^{26m}	6346 ± 5 (4) 6351 ± 10 (13) 6339.5 ± 4.5 (14) 6346.2 ± 2.6 (2)	6345 ± 2
Cl^{34}	1534 ± 3(13) 1525.2 ± 1.1 (15) 1526 ± 2 (16) 1527.7 ± 2.2 (2)	1525.6 ± 0.92
Sc^{42}	684.5 ± 1.2 (13) 680.98 ± 0.62 (15)	681.7 ± 0.55
V^{46}	425.3 ± 2.0 (17) 422.47 ± 0.39 (14) (15) 423.4 ± 2.0 (18) 422.28 ± 0.23 (19)	422.4 ± 0.19
Mn^{50}	285.1 ± 0.9 (17) 282.8 ± 0.3 (20) 2784.0 ± 0.4(18) 282.72 ± 0,26 (15)	283.07 ± 0.17
Co^{54}	193.1 ± 0.8 (17) 193.0 ± 0.3 (21) 193.4 ± 0.4 (18) 193.28 ± 0.18 (14)	193.2 ± 0.14

Table 1b : Decay Energy for superallowed β-branches.

Decaying Nucleus	Measured Decay Energy Q_{EC} (keV)		Average Value
C^{10}	1910.1 ± 0.6 (5)		1910.1 ± 0.6
O^{14}	2832.3 ± 0.6 (22) 2832.2 ± 1.5 (10) 2829.91 ± 0.8 (26)	2832.39 ± 0.6 (23) 2380.32 ± 0.08 (24) 2830.78 ± 0.37 (26)	2830.4 ± 0.076
Al^{26m}	4231.6 ± 1.6 (10) 4230.3 ± 2.2 (18)	4232.7 ± 0.6 (26) 4232.16 ± 0.61 (27)	4232.2 ± 0.4
Cl^{34}	5488.7 ± 2.5 (18) 5489.4 ± 1.9 (16) 5491.78 ± 0.55 (23) 5489.5 ± 1.9 (28)	5492.42 ± 0.23 (29) 5490.4 ± 2.3 (18) 5492.2 ± 0.4 (26)	5492.2 ± 0.18
Sc^{42}	6421.9 ± 2.2 (18) 6423.5 ± 2.6 (18)	6423.7 ± 0.4 (26)	6432.6 ± 0.39
V^{46}	7040.8 ± 2.8 (18) 7052.7 ± 1.8 (30)	7050.4 ± 0.6 (26)	7050 ± 0.55
Mn^{50}	7629.8 ± 2.1 (18) 7631.9 ± 2.8 (18)	7631.9 ± 0.4 (26) 7633.6 ± 1.8 (31)	7631.9 ± 0.38
Co^{54}	8240.5 ± 1.8 (21) 8244.2 ± 3.0 (18)	8241.6 ± 0.6 (26)	8241.4 ± 0.56

from them calculate a set of F.t. The resulting F.t. values are seen to be consistent with each other and best average will be determined.

DETAILS OF THE CALCULATION

The f.t values of superallowed nuclear beta-decays depend upon the transition energy, Q_{ec}, and its partial half-life, t,. To determine t, both the branching ratio for the transtion of interest and the half-life of the state must be measured. The relevant experimental data are surveyed in Tables (1-3).

In treatment of the data, only the measurements published after 1970 was considered. References have been noted in Tables.

To calculate the average values of the terms given in the data the weighted averages according to following equations were used.

$$\bar{x} \pm \delta \bar{x} = \sum W_i x_i / \sum W_i \pm (\sum W_i)^{-1/2}$$

$$W_i = \frac{1}{(\delta x_i)^2}$$

Uncertainities on the average were listed in Tables (1-3).

The partial half-lives, t, were obtained according to the formula;

$$t = \frac{t\,1/2}{BR} 100 \,(1 + \frac{1}{100} EC)$$

Where B.R is the branching ration and EC the electron capture fraction.

The corrected F.t values from Table 3 yield a weighted average of : 3080, 9 ± 0,73

RESULT AND CONCLUSIONS

It should be noted that the agreement among the individual values is good enough only for the Sc^{42}, V^{46}, Mn^{50}, and Co^{54}. Deviations in the values of C^{10}, O^{14}, Mg^{22}, Al^{26m}, Cl^{34} may arise from the correction terms. (δ_R and δ_c) They should be reexamined. It is possible to test for vector coupling constant, Gv, and several quark mixing elements by using this Ft value despite some discrepancies.

In the calculations, the scale factor was not considered to define the average values but it can be seen that there is an agreement between the results of this work and ref. (2) but not ref. (3). At large values of Q_{ec}, the discrepancies are very insignificant changes in the f values.

The F.t values which include both outer radiative corrections and effects of charge-dependent force are listed in Table 3 and presented graphically in Figure 1.

According to literature (3) the Ft value for Al^{26m} is the nearest to the actual value but it can be seen from graph that the last six points nearly have the same Ft value. The Ft value is an average of several decays rather than Al^{26m} alone.

The resulting Ft value, 3080, 9 ± 0,73 sn can be used in conjunction with data on the weak decays of hyperons and mesons to examine the universality of weak interaction processes.

Figure 1: The corrected experimental Ft values plotted as a fuction of the mass number, A.

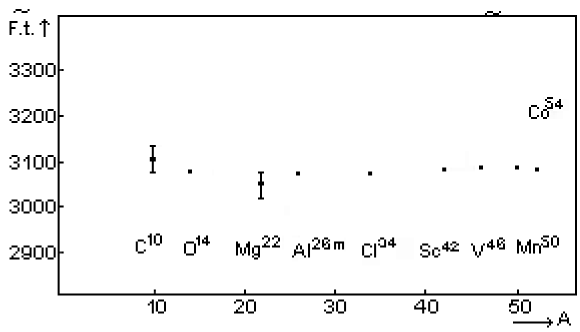

Table 2: Measured Branching Ratio and Electron capture for superallowed β branches.

Decaying Nucleus	Branching (%) B.R ratio	Electron (%) E.C (38) capture
C^{10}	1.465 ± 0.014 (32)	0.31
O^{14}	99.336 ± 0.010 (33) (34) 99.332 ± 0.011 (35)	0.091
Mg^{22}	54.9 ± 1.1 (1)	0.070
Al^{26m}	100[(a)]	0.084
Cl^{34}	>99.988 ± 100 (36)	0.081
Sc^{42}	99.9954 ± 0.0022 (37)	0.097
V^{46}	100[(a)]	0.098
Mn^{50}	100[(a)]	0.103
Co^{54}	100[(a)]	0.106

a) The branching ratios for all superallowed transitions from T_z=0 nuclei are 100% (39).

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Decaying Nucleus	(a) f	(b) f*	Partial half-life t(msn)	(c) δ_R (%)	(e) δ_C(%)	(g) t.f (sn)	* Ft (sn)	(2) Ft (sn)	(3) Ft (sn)
T_{zi}=-1 C^{10}	(d) 2.3257 ± 0.0063	2.328	1316588 ± 12580	1.68	0.27	(d) 3061.98 ± 30.4	3105 ± 30.4	(d) 3108 ± 31	2971
T_{zi}=-1 0^{14}	42.709 ± 0.027	43.167	71224.25 ± 18	1.57	0.33	3041.9 ± 2.06	3079.4 ± 2.06	3075.5 ± 3.9	3132 ± 10
T_{zi}=1 Mg^{22}	(d) 421.8 ± 1.5		7151.3 ± 146	1.57	0.34	3016.4 ± 22	3053.3 ± 22	(d) 3057 ± 64	
T_{zi}=0 Al^{26m}	477.83 ± 0.17	476.429	6350.3 ± 2	1.61	0.34	3034.2 ± 1.44	3072.5 ± 1.44	3072.9 ± 3.7	3086 ± 8
T_{zi}=0 Cl^{34}	1997.8 ± 0.37	1975.49	1526.8 ± 0.92	1.68	0.85	3050.6 ± 1.92	3075.8 ± 1.92	3075.9 ± 4.7	3138 ± 19
T_{zi}=0 Sc^{42}	4467.6 ± 1.1	4487.16	682.4 ± 0.55	1.82	0.48	3048.69 ± 2.56	3089.2 ± 2.56	3089.3 ± 7.5	3111 ± 9
T_{zi}=0 V^{46}	7199.2 ± 3.9	7212.65	422.8 ± 0.19	1.88	0.40	3044 ± 2	3088.8 ± 2	3088.6 ± 4.3	3115 ± 8
T_{zi}=0 Mn^{50}	10727.8 ± 3.1	10708.1	283.36 ± 0.17	1.95	0.43	3040.2 ± 2.02	3086.1 ± 2.02	3085.9 ± 5.7	3102 ± 9
T_{zi}=0 Co^{54}	15740.8 ± 3.3	15815.5	193.4 ± 0.14	2.01	0.60	3044 ± 2.2 Avrage F.t	3086.5 ± 2.2 3080.9 ± 0.73	3087.5 ± 4.5 3080.1 ± 2.4	3103 ± 17

a) Results were taken from ref. (2)

b) Results were taken from ref. (3) to compare with (a)

c) Electron capture and radiative corrections taken from Ref. (1)

d) Results were taken from ref. (1)

e) Charge dependent corrections taken from (2) but the uncertainities weren't considered.

g) The values in f [(a)] were used to calculate f.t values

* Defined eq. (2)

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