

COMPARATIVE HALF-PERIOD OF FERMI SUPERALLOWED
 $^{38\text{m}}\text{K} (\beta^+) ^{38}\text{Ar}$ TRANSITION

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The half-life of Fermi β decay of $^{38\text{m}}\text{K}$ produced in the reaction $^{39}\text{K} (\gamma, n) ^{38\text{m}}\text{K}$ has been measured and the *effective* ft -value has been calculated, including the outer radiative corrections and the effects of different nuclear charge-dependent forces. Comparison is made with the previous measurements.

Fermi superallowed $0^+ \rightarrow 0^+$, β transitions in case of Wigner or *mirror* pairs of elements have created a lot of interest in the precise measurements of ft -values, because of their relevance to the weak interaction theory. According to the Conserved Vector Current (CVC) hypothesis, these values, after small electromagnetic corrections should be identical. Further assuming this hypothesis, and universality in the Cabibbo sense, the comparison of such decay with that of the muon furnishes an information on the intimate anatomy of the β -decay process and inner structure of the nucleon.

Comparative half-life (ft) for the superallowed beta decay of $^{38\text{m}}\text{K}$ has been studied very recently by a number of investigators^{1,2}). Yet, in view of the novelty of the sample the experiment was repeated. This was because of the characteristics of the potassium borohydride (KBH_4) available for (γ, n) reaction in ^{39}K , with no competing reaction except with a single easily separable small activity due to that of the ground state of ^{38}K , and other special characteristics of this chemical compound, described elsewhere³).

Further to avoid contamination due to any other short-lived activity, a specially constructed *proportional flow counter*, with an ionization nickel chamber, was used. The chamber was set in the photon beam of the betatron. The flow of

the gas through the chamber and high voltage supply to the betatron were arranged by means of remote controlled leads from a distant operation room. Each cylindrical sample of KBH_4 , weighing 25 g, was irradiated at 22 MeV bremsstrahlung energy for about 5 s. The signal from the flow counter was fed to a single channel detection unit which was further connected to a Brush Oscillograph tape-recorder (calibrated with 60 cycles A. C. pulses). Initially several hundred counts/s were obtained for the decay curve of the activity under reference. A specially designed electronic circuit which was used to interlock the operational circuit of betatron with of the Brush Oscillograph, was converted into a cyclic device for an automatic control of the irradiation time as well as the counting period of each observation. A device of this type has been used for a study of short lived activities⁴⁾.

In order to establish a background due to long period (7.7 min) $^{38\text{K}}$ activity, in the reaction $^{39}\text{K}(\gamma, n)^{38\text{K}}$, the decay was followed for about one hour each time. Thirteen such observations were made. By the help of decay curves, after subtracting this background, the data obtained was analysed using the method of *least squares*. The value of the half-life obtained from the data turned out to be $t_{1/2} = 927 \pm 1.1$ ms.

To compute the *effective ft*-value for the pure superallowed Fermi β decay of $^{38\text{mK}}$, the partial half-life of this decay to the ground state of ^{38}Ar is required. The measured half-life must, therefore, be corrected for any competing decays. One such correction is to be applied for electron capture as $\pm 0.08\%$ ⁵⁾. We also assume that the other branching effect is very small and negligible²⁾, then corrected half-life is $t = 928 \pm 1.1$ ms.

The Fermi integral function may be taken as

$$f(Z, E_0) = \int_0^{F_0} F(Z, E) P^2 (E_0 - E)^2 dp$$

where P and E are the β -momentum and total energy and E_0 is the end point total energy in units of electron mass. $F(Z, E)$ is the Fermi function evaluated at the centre of the nucleus tabulated by Behrens and Jänecke⁵⁾.

For the evaluation of the above integral, the latest determined²⁾ value of beta end-point energy may be taken as $= 5021.2 \pm 3.4$ keV.

With this end-point energy, the value of the Fermi function $F(Z, E_0)$ from the relevant tables by Behrens and Jänecke⁵⁾ is 3300.6 ± 10.4 .

Further, including the correction for the screening effect of the orbital electron⁵⁾ as $+0.175\%$ the value of $F(Z, E_0)$ becomes 3306.4 ± 10.4 .

Also applying the correction $C(E)$, for the variation of the Fermi function over the nuclear volume as well as second forbidden effects⁷⁾, the energy averaged value of which, $\overline{C(E)}$ was calculated by Squier et al.²⁾ by using the tables⁵⁾ as $(1 - 0.353\%)$, $f(Z, E_0) \cdot \overline{C(E)} = 3294.7$.

With the present value of half-life, the *effective ft*-value may be given by

$$f(Z, E_0) \cdot t_{1/2} \overline{C(E)} = 3057.5 \pm 8.5 \text{ s,}$$

ft (with further *outer* radiative correction⁸⁾ δ_R^1 up to the order α^9) as $+0.976\%$) = 3087 ± 8.5 s,

ft (with further *outer* radiative correction δ_R^1 to the order $(Z^2\alpha^3)^{10}$) as $+0.779\%$) = 3111 ± 8.5 s,

ft (with charge-dependent correction δ_c as -0.70% , as calculated very recently by Towner et al.¹¹⁾ using Saxon-Woods wave functions) = 3089 ± 8.5 s.

Hence the resultant *effective ft*-value defined by

$$F_t = F(Z, E_0) \cdot t_{1/2} \overline{C(E)} (1 + \delta_R^1) (1 - \delta_c)$$

becomes 3089 ± 8.5 s.

The present value of half-life determined i. e. 927 ± 1.1 ms is slightly higher than those recently measured as 922.3 ± 1.1 ms¹⁾; $925.6 \pm .7$ ms²⁾, and an adopted average of 924.6 ± 0.7 ms¹⁵⁾; yet from the following table it is clear that the present *effective ft*-value or *comparative half-life* is in fair agreement with those already reported. Evidently this is due to the latest value of the correction δ_c applied above.

TABLE

Decay	F_t/s
$^{140}(\beta^+)^{14}\text{N}$	$3087 \pm 11^{c,d}$ 3091.3 ± 4.2^a
$^{26\text{m}}\text{Al}(\beta^+)^{26}\text{Mg}$	$3079 \pm 4^{c,d}$ 3081.0 ± 4.1^a
$^{34}\text{Cl}(\beta^+)^{34}\text{S}$	$3078 \pm 7^{c,d}$ 3078.5 ± 5.5^a
$^{38\text{m}}\text{K}(\beta^+)^{38}\text{Ar}$	3089 ± 8.5 (present work) 3088 ± 10^b 3085.9 ± 9.9^a
$^{42}\text{Sc}(\beta^+)^{42}\text{Ca}$	3093^e 3079.0 ± 7.2^a
$^{46}\text{V}(\beta^+)^{46}\text{Ti}$	3090 ± 8^c 3080.3 ± 8.2^a
$^{50}\text{Mn}(\beta^+)^{50}\text{Cr}$	3110 ± 7^c 3084.3 ± 4.9^a
$^{54}\text{Co}(\beta^+)^{54}\text{Fe}$	3084 ± 6^d 3092 ± 11^e 3090.7 ± 6^a

Effective, F_t -values of Fermi superallowed beta decays.

a Ref. 1; b Ref. 2. c Ref. 12; d Ref. 13;

e Ref. 14.

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POREDBENO VRIJEME POLURASPADA FERMIJEVOG SUPERDOZVO-
LJENOG PRIJELAZA $^{38m}\text{K}(\beta^+)^{38}\text{Ar}$

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Izmjereno je vrijeme poluraspada Fermijevo β raspada ^{38m}K proizvedenog reakcijom $^{39}\text{K}(\gamma, n)^{38m}\text{K}$; izračunata je *efektivna* ft-vrijednost uzevši u obzir vanjske radijativne korekcije kao i efekte ovisnosti nuklearnih sila o naboju. Rezultati su uspoređeni sa prethodnim mjerenjima.