Endt, P. M.
Kluyver, J. C.
Van der Leun, C.
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THE REACTION ^{25}Mg (p,γ) ^{26}Al

(II Conclusions)

by P. M. ENDT, J. C. KLUYVER and C. VAN DER LEUN

Physisch Laboratorium der Rijks-Universiteit te Utrecht, Nederland

Synopsis

The measurements described in the preceding paper (I) are used to obtain the position, spin and isobaric spin of energy levels in ^{26}Al.

All the observed intensive high-energy γ-rays can be explained as transitions from resonance levels to the levels found by Browne [7]) from the ^{28}Si$(d, \alpha)^{26}$Al reaction and to one additional level at $E_x = 2.57 \pm 0.04$ MeV. The low-energy γ-rays fit the same level scheme, plus one more additional level at $E_x = 0.235 \pm 0.009$ MeV. The latter level is actually the first excited state in ^{26}Al, which turns out to be an isomeric state decaying by β^+ emission with the long known half life of 6.6 sec.

Spins J, parities and isobaric spins T can be assigned as follows: $E_x = 0$ ($J = 5^+$, $T = 0$), $E_x = 0.235$ MeV ($J = 0^+$, $T = 1$), $E_x = 0.419$ MeV ($J = 3^+$, $T = 0$), $E_x = 1.055$ MeV ($J = 1^+$, $T = 0$), $E_x = 1.750$ MeV ($J = 2^+$, $T = 0$), $E_x = 2.064$ MeV ($J = 2^+$, $T = 0$). The resonance level at $E_x = 6.73$ MeV has $J = 4^-$, $T = 0$. Tentative assignments to the other resonance levels will be discussed.

The 6.6 sec β^+ decay is remarkable by being one of the few known $0^+ \rightarrow 0^+$ transitions. The β^+ endpoint can best be arrived at by using a cycle involving the 0.820 MeV γ-ray from ^{25}Mg$(p, \gamma)^{26}$Al, the Q-value of the ^{28}Si$(d, \alpha)^{26}$Al transition to the 1.055 MeV level in ^{26}Al, and a reevaluation of the ^{28}Si—^{26}Mg mass difference. This yields $E_{\beta^+} = 3.225 \pm 0.015$ MeV, and $ft = 3200 \pm 80$ sec. The ft value of this β^+ transition can now be used for direct evaluation of the Fermi coupling constant g_F. The result is: $g_F = (1.391 \pm 0.017) \times 10^{-49}$ erg cm^3.

§ 7. *Excitation energies of levels in ^{26}Al.* The position of the ^{26}Al ground state has already been discussed in a preceding paper [5]). It is found from the strong ground-state γ-ray transition observed at the $E_p = 441$ keV resonance (resonance C). The energy of this γ-ray is $E_\gamma = 6.77 \pm 0.08$ MeV, which entails a ^{26}Al–^{26}Mg mass difference of 3.96 ± 0.08 MeV, if the ^{25}Mg + p — — ^{26}Mg mass difference is taken as 10.323 ± 0.012 MeV [15]). A better value of 4.01 ± 0.04 MeV can be obtained for the ^{26}Al–^{26}Mg mass difference if also γ-ray cascade transitions are taken into account. This agrees very well with a value of 4.012 ± 0.015 MeV, which is computed from Browne's [7]) Q-value of 1.416 ± 0.008 MeV for the ^{28}Si$(d, \alpha)^{26}$Al ground-state transition, from a ^{26}Mg–^{28}Si mass-defect difference of 4.689 ± 0.013 MeV (see § 9) and from a d–α mass-defect difference of 10.117 ± 0.001 MeV [16]).

An ^{26}Al mass defect of -4.553 MeV results from Browne's ground-state Q-value and Li's [15]) ^{28}Si mass defect.

Excited states in ^{26}Al are found by Browne at $E_x = 0.418$, 1.052, 1.750, (1.846) and 2.064 MeV. These levels will be labelled (2), (3), (4) and (5). The doubtful level at 1.846 MeV is not labelled, as it is not found in the present work. No errors were given for the excitation energies. We shall assume errors of 8 keV. The ^{26}Al first excited state, labelled (1) which is not found by Browne, will be discussed below.

At all ^{25}Mg$(p, \gamma)^{26}$Al resonances a γ-ray is found of (average) energy $E_\gamma = 0.419 \pm 0.003$ MeV (see Table II). This agrees excellently with the excitation energy of 0.418 ± 0.008 MeV found by Browne for level (2) and thus corresponds to the ground-state de excitation of level (2). Level (2) is fed at all resonances by direct transitions from the resonance level. The energy of this γ-ray increases slowly with proton energy (see Table II) from about 6.2 MeV at the lowest to 6.5 MeV at the highest resonance. Another γ-ray, feeding level (2), and found at all resonances is the one with average energy 1.34 ± 0.02 MeV. From Browne's Q-values one finds 1.331 ± 0.008 MeV for transitions from level (4) to level (2).

Level (3) is fed directly from the resonance level only by very weak transitions ($E_\gamma = 5.8$ MeV) at the two highest resonances G and H (see Table II). It is also fed, at four of the six resonances, by weak γ-rays with average energy $E_\gamma = 1.002 \pm 0.010$ MeV. One finds 1.012 ± 0.008 MeV for transitions between Browne's levels (5) and (3). For the deexcitation of level (3) see below.

Direct transitions from resonance levels feed also level (4) at resonances A and D ($E_\gamma = 4.82 \pm 0.04$ and 5.04 ± 0.07 MeV). This level deexcites to level (2) as mentioned above. Level (5) is fed at all resonances except resonance A by direct transitions from the resonance level ($E_\gamma = 4.6-4.8$ MeV). It deexcites to level (3). The weak γ-ray of about 1.65 MeV found at resonances B and H might correspond to transitions from level (5) to level (2) with an energy difference of 1.646 MeV computed from Browne's Q-values.

Strong γ-rays are found at resonances D, G and H of $E_\gamma = 4.22 \pm 0.06$, 4.27 ± 0.05 and 4.34 ± 0.05 MeV. They could be explained as direct transitions to a new level at $E_x = 2.57 \pm 0.04$ MeV. The deexcitation of this level is still unknown.

In the discussion given above all high-energy γ-rays ($E_\gamma > 4$ MeV) and all low-energy γ-rays ($E_\gamma < 1.7$ MeV), except the γ-ray at 0.82 MeV, have found a natural explication. The γ-rays between 1.7 and 4 MeV are relatively weak, and their assignment (photo-or pair peak) is difficult. They will necessitate the assumption of one or two more levels above $E_x = 2.6$ MeV.

Finally the γ-ray with average energy 0.820 ± 0.004 MeV, found at all resonances except resonance C, is left unexplained. Arguments will be put forward in § 8 to show that this γ-ray corresponds to the deexcitation of level

(3) at 1.055 MeV to level (1), not found by Browne, at an excitation energy of 0.235 ± 0.009 MeV. The peculiar properties of this level will be discussed in § 8.

In Fig. 7 the ^{26}Al level scheme is presented, in which the levels discussed above are incorporated.

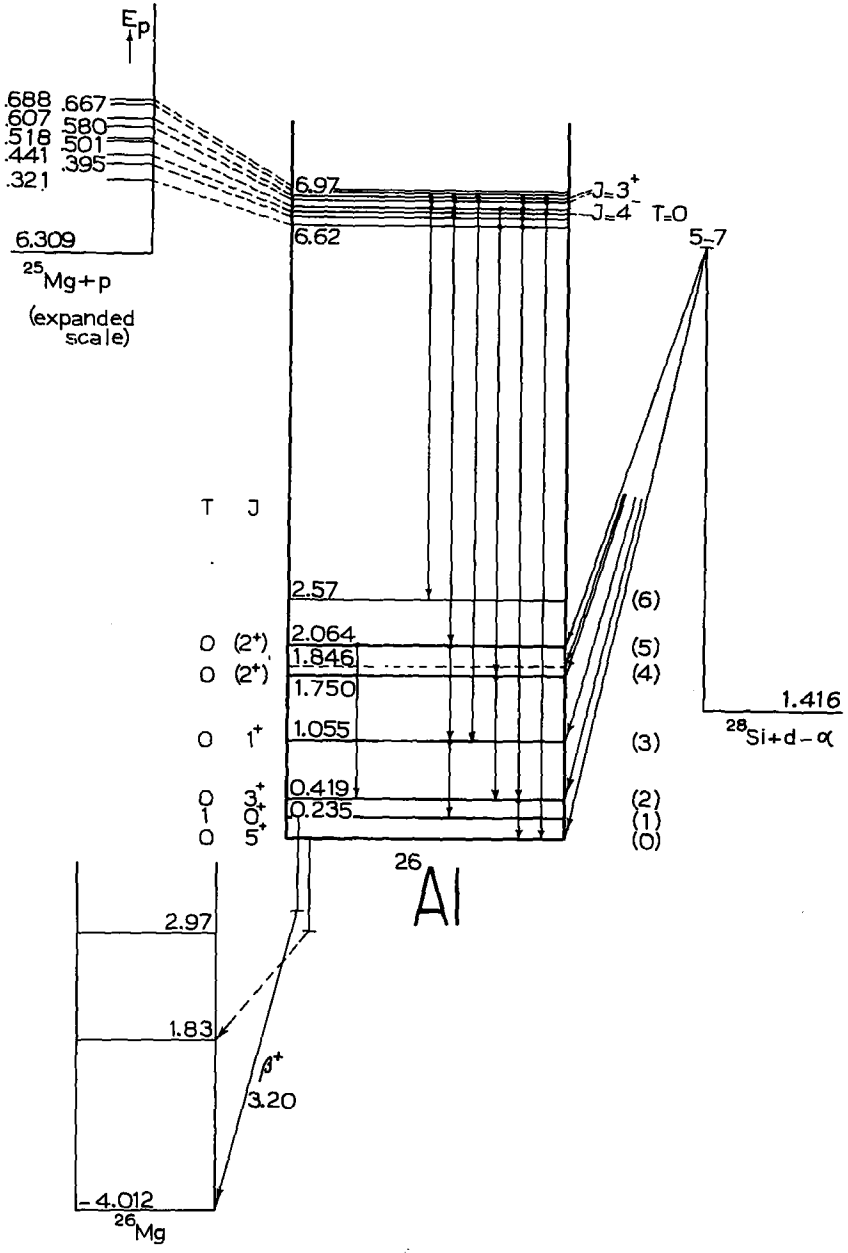

Fig. 7. Level scheme of ^{26}Al.

§ 8. *Spins and isobaric spins of ^{26}Al levels. a)* The ground state. The nucleus ^{26}Al belongs to the series of self-conjugated odd-odd nuclei. In this series ^{2}H, ^{6}Li, ^{10}B, ^{14}N, ^{22}Na [3] [4]) and ^{30}P [6]) have a ground state with isobaric spin $T = 0$, while ^{34}Cl has a $T = 1$ ground state [2]). One now knows that the ^{26}Al ground state has also $T = 0$ character, because this state was found by means of the ^{28}Si$(d, \alpha)^{26}$Al reaction by Browne [7]) (see § 1).

The nucleus ^{26}Al is known to decay by positron emission with a half life of 6.6 sec [4]). From a recent accurate positron absorption analysis Haslam et al. [17]) found 3.2 ± 0.1 MeV for the endpoint energy. However, from the position of the ^{26}Al ground state (see § 7) one would compute 2.99 MeV for the positron endpoint, if the decay were to proceed directly to the ^{26}Mg ground state. The conclusion is, that the 6.6 sec positron decay does not proceed from the ^{26}Al ground state, but from an excited (isomeric) state at an excitation energy of about 0.2 MeV. The fact that the ground state decay has not been experimentally observed, is then explained by assuming that the ^{26}Al ground state has a high spin value, entailing a long half life for the ground state decay.

The spin of the ground state would have to be at least $J = 4$. If the spin were $J = 0$ or 1 the decay to the ^{26}Mg ground state would be allowed, if the spin were $J = 2$ or 3 the decay could proceed to the 1.83 MeV excited state in ^{26}Mg (assumedly with spin $J=2^+$) through an allowed transition. An upper limit for the ^{26}Al ground-state spin is found from shell-model considerations. A $d_{5/2}$ proton and $d_{5/2}$ neutron couple to at most $J = 5$.

Actually it can be shown [18]), that in selfconjugated odd-odd nuclei the states with odd J are symmetric for interchange of the two odd nucleons, and hence have $T = 0$, while those with even J are antisymmetric, and thus have $T = 1$. This holds if one assumes that: *a)* the odd proton and odd neutron are in the same-subshell ($d_{5/2}$ in the case of ^{26}Al), and *b)* the j–j coupling approximation is valid. Low-energy $T = 0$ states in ^{26}Al must then be expected with $J = 1$, 3 and 5 and $T = 1$ states with $J = 0$, 2 and 4.

The result from these combined arguments is that the ^{26}Al ground-state spin is most probably $J = 5^+$. The ground state presumably decays to the $J = 2^+$ 1.83 MeV excited state in ^{26}Mg through a second forbidden transition with a decay energy of 2.18 MeV. If a log ft-value is assumed of 13.0, this would result in a half life of about 40,000 years, too short to make ^{26}Al stable, but long enough to prevent easy experimental detection *). A recent search for stable ^{26}Al in natural magnesium had a negative result [19]).

b) Level (1). The 0.2 MeV first excited state in ^{26}Al, not found from the ^{28}Si$(d, \alpha)^{26}$Al reaction, can almost certainly be identified as the $T = 1$, $J = 0^+$ state, belonging to the same isobaric spin triplet as the ground state of ^{26}Mg. The energy difference of this state and the ^{26}Mg ground state should

*) See "Note added in proof" at the end of § 9.

be equal to the Coulomb energy difference minus the neutron-proton mass difference:
$\Delta E = 6Z\ e^2/5\ r_0\ A^{1/3} - (m_n - m_p)\ c^2$, where Ze is the Mg nuclear charge ($Z = 12$) and $r_0\ A^{1/3}$ the nuclear radius. The value of r_0 to be used here can best be computed by comparison with mass differences in neighbouring charge triplets. One finds $r_0 = 1.46 \times 10^{-13}$ cm for $A = 22$ [20]), $r_0 = 1.35 \times 10^{-13}$ cm for $A = 30$ [6]) and $r_0 = 1.35 \times 10^{-13}$ cm for $A = 34$ [21]). Using $r_0 = (1.39 \pm 0.05) \times 10^{-13}$ cm as an average value one computes $\Delta E = 4.23 \pm 0.18$ MeV, as compared to an experimental value of 4.247 ± 0.015 MeV (see § 9). This is a good agreement, but obviously the margin allowed in the choice of r_0 is rather large.

A much better proof of the $J = 0^+$, $T = 1$ character of level (1) can be found from a computation of the ft value of the corresponding positron decay. This ft value should be the same for all $0^+ \rightarrow 0^+$ transitions between states belonging to the same charge triplet. One finds (see § 9):

$$\text{ft} = 3275 \pm 75 \text{ sec for } {}^{14}O(\beta^+){}^{14}N^*,$$
$$\text{ft} = 3200 \pm 80 \text{ sec for } {}^{26}Al^*(\beta^+){}^{26}Mg \text{ and}$$
$$\text{ft} = 3210 \pm 140 \text{ sec for } {}^{34}Cl(\beta^+){}^{34}S.$$

This beautiful agreement shows better than anything else the correctness of the $J = 0^+$, $T = 1$ assignment to level (1) in ^{26}Al. A change in the position of this level by 100 keV would change the ft value by as much as 450 sec.

It is clear that level (1) decays by positron emission, rather than by γ-ray emission to the ^{26}Al ground state, because the spin change connected with the latter transition would have the large value $\Delta J = 5$. No γ-ray of 0.23 MeV is found at any of the $^{25}Mg(p, \gamma)^{26}Al$ resonances investigated.

c) Level (2). From the discussion of the ^{26}Al ground state it follows that one may expect low $T = 0$ states in ^{26}Al with spin $J = 3^+$ and $J = 1^+$, once a spin $J = 5^+$ is assigned to the ground state. Level (2) must then have $J = 3^+$, as it decays to the ground state, while a $J = 1^+$ state would be expected to decay to level (1) with $J = 0^+$.

d) Level (3). The third excited state a 1.055 ± 0.008 MeV has also isobaric spin $T = 0$. It decays to level (1) and not to (0) or (2), which makes the most probable spin assignment $J = 1^+$ *).

e) Other low levels. The $T = 0$ level (4) at 1.750 MeV decays to level (2), and not to levels (0) or (1). The most probable spin assignment is then $J = 2$ or 3. However $J = 3$ is reasoned out, because no direct transitions to this level are observed at resonance C ($J = 4^-$).

The $T = 0$ level (5) at 2.064 MeV decays chiefly to level (3) and perhaps also to level (2). The most probable spin assignment would also be $J = 2$.

*) Actually it was suggested by Dr. D. C. Peaslee in a letter to the authors to look for a 0.8 MeV γ-ray, feeding level (1).

One should also expect a $J = 2^+$ $T = 1$ level around $E_x = 2.06$ MeV belonging to the same charge triplet as the first excited state in ^{26}Mg at $E_x = 1.83$ MeV. No definite indication of the existence of such a level has been found, but there are still discrepancies connected with the intensities of the γ-ray deexciting level (5), which might perhaps be explained if (5) were a doublet level. E.g. at resonance B, level (5) is fed by an intensive direct transition from the resonance level, while the 1.00 MeV (5) $\rightarrow$ (3) transition is not particularly strong.

Above or partially mixed with the $(d_{5/2}, d_{5/2})$ states one may expect $(d_{5/2}, s_{1/2})$ states in ^{26}Al. There are four of these: $T = 0$, $J = 2^+$ and 3^+, and $T = 1$, $J = 2^+$ and 3^+. Levels (4) or (5) might be of this character.

f) The resonance levels. The resonance levels are formed by adding a proton to the ^{25}Mg nucleus with $J = 5/2^+$. One might expect *s*- and *p*-wave capture, and perhaps *d*-wave capture at the higher resonances, but the small Coulomb barrier penetration would prevent capture of protons with higher orbital momentum. The corresponding resonance level spins are $J = 2^+$ and 3^+ for *s*-protons, $J = (1, 2, 3, 4)^-$ for *p*-protons and $J = (0, 1, 2, 3, 4, 5)^+$ for *d*-protons.

The only resonance showing a strong transition to the $J = 5^+$ ^{26}Al ground state is resonance C. As it decays at the same time to level (2) ($J = 3^+$) the spin of this resonance should be $J = 4$. The parity should be negative, as a *d*-wave resonance is improbable at this low proton energy. It then decays by $E1$ transitions to levels (0) and (2). The radiation width computed for an $E1$ transition of $E_\gamma = 6.7$ MeV from Weisskopf's formula [22]) is 75 eV. The experimental total radiation width however, found for resonance C from § 6 by putting $J = 4$ in the value given for $(2J + 1)\,\Gamma_\gamma$, is only 0.08 eV. A natural explication of this discrepancy can be found in the operation of Radicati's [23]) selection rule, which forbids $E1$ transitions between two states of isobaric spin $T = 0$. No estimates have been made of the slowing down factor to be expected in this case, but a rough guess is that it might easily amount to a factor of 10^{-2} [24]). We conclude that resonance level C, at $E_x = 6.73$ MeV, has $J = 4^-$, $T = 0$, character.

Resonances G and H are almost identical. If we assume $J = 3^+$ for their spin, the strong transitions to level (2) ($J = 3^+$)would be $M1$, and the weak transitions to the ground state ($J = 5^+$) and to level (3) ($J = 1^+$)would be $E2$.

Resonance levels A, B and D decay to level (2) ($J = 3^+$), but not to levels (0) ($J = 5^+$), (1) ($J = 0^+$) or (3) ($J = 1^+$). The best assignment would be $J = 3^-$, $T = 0$ for all three resonances, but this leaves unexplained their different modes of decay, showing up in the intensity differences of transitions to levels (4), (5) and (6).

It is expected that γ-ray angular distribution measurements, which are planned for the near future, will make it possible to say more about the

resonance spins. These measurements will also serve as a check on spin assignments to lower levels.

g) Comparison with theory. It was shown above that experiment leads to the following spin order of the lower states in ^{26}Al, in order of increasing excitation energy: $J = 5, 0, 3, 1$. Two more $(d_{5/2}, d_{5/2})$ states are expected, those with $J = 2$ and 4 (both with $T = 1$). Their position is still unknown, but they are certainly situated above the $J = 1$ state.

Two authors have calculated the spin order, to be expected for a $(d_{5/2}, d_{5/2})$ state in the j–j coupling scheme, making use of different approximations for the interaction between the two nucleons, which is regarded as a perturbation on the central field in which they move.

By De-Shalit [18]) the interaction was taken as:

$$V = \{1 - |a| + a(\boldsymbol{\sigma}_n \boldsymbol{\sigma}_p)\}\, \delta(\boldsymbol{r}_n - \boldsymbol{r}_p), \tag{1}$$

where the parameter a, taking values between -1 and $+1$, measures the amount of spin dependence introduced. This approximation, corresponding to very short range forces, yields the same spin order for the four lowest states in ^{26}Al as found by experiment, if a is put equal to 0.19. For other positive values of a the order $J = 5, 3, 1$ for $T = 0$ states is retained, but the $J = 0$ level either occurs as a low ground state or as a very high excited state.

The interaction taken by Edmonds and Flowers [25]) is of the form:

$$V = (\boldsymbol{\tau}_n \boldsymbol{\tau}_p)\, \{1 + 1.15\, (\boldsymbol{\sigma}_n \boldsymbol{\sigma}_p)\} \exp\, (- |\boldsymbol{r}_n - \boldsymbol{r}_p|^2/a^2), \tag{2}$$

where $\boldsymbol{\tau}$ is the isobaric spin operator. The unperturbed wave functions are of the harmonic oscillator type showing the radial dependence:

$$\varphi_l(r) = \text{const.}\, r^l \exp\, (- \tfrac{1}{2} r^2/a_0^2).$$

The spin order of $(d_{5/2}, d_{5/2})$ states is calculated for the following values of the range parameter β (defined as $\beta = a/a_0$): $\beta = 0$, 0.6, and 1.2. For $\beta = 0.6$ the experimentally observed spin order is reproduced: $J = 5, 0, 3, 1$. Calculations have also been made by Edmonds and Flowers for interactions of other symmetry character or of other radial dependence, and it seems that they yield essentially the same level order, as found from the symmetrical force of Gaussian radial dependence given by (2).

As a conclusion one may say that both the calculations of De-Shalit, and of Edmonds and Flowers, yield a level order for ^{26}Al in agreement with experiment, for appropriate values of the interaction parameters. On the other hand, one must certainly not attach too great a value to this agreement. The two-particle approximation, making use of a certain interaction, fitting the ^{26}Al level order, would certainly yield wrong results for the other $(d_{5/2}, d_{5/2})$ odd-odd nuclei. Actually their ground-state spins are all different, in accordance with King and Peaslee's [45]) empirical rule (which, by the way, also predicts the ^{26}Al spin correctly).

§ 9. *Determination of the Fermi interaction constant.* The β^+ transition from the isomeric state in ^{26}Al at 235 keV (level 1)) to the ^{26}Mg ground state is a $0^+ \rightarrow 0^+$ transition. From the ft values of this group of transitions between states of the same isobaric spin the Fermi coupling constant g_F may be directly derived.

Recently Gerhart [26]) has evaluated g_F in this way from new accurate determinations of the half life and end-point energy of the $^{14}O(\beta^+)^{14}N^*$ decay. The direct measurements of the β^+ end-point energy of ^{26}Al are not sufficiently accurate to allow an evaluation of g_F with a precision comparable to Gerharts. However, a better value may be derived indirectly from a new evaluation of the ^{28}Si–^{26}Mg mass difference, the Q-value measurement of the ^{28}Si$(d, \alpha)^{26}$Al reaction to level (3) in ^{26}Al by Browne, and the measurement of the energy of the γ-ray transition between levels (3) and (1) observed in the ^{25}Mg$(p, \gamma)^{26}$Al reaction.

To this purpose the energy of this 0.82 MeV γ-ray has been measured in resonance G several times with great precision relative to the 661.6 keV γ-ray from ^{137}Cs and the 1277 keV γ-ray from ^{22}Na. Averaging the results obtained in these measurements, viz. 822, 817, 819 and 824 keV a final value of 820 $\pm$ 4 keV was found. The less precise determinations at other resonances are in reasonable agreement with this value.

Browne finds $Q = 0.364 \pm 0.008$ MeV for the α-group of ^{28}Si$(d, \alpha)^{26}$Al proceeding to level (3). Another chain between ^{28}Si and level (3) in ^{26}Al consists of Browne's value of $Q = -0.648 \pm 0.008$ MeV for the α-group to level (5) and our value of 1.002 ± 0.010 MeV for the γ-ray transition between the levels (5) and (3). The weighted average brings the excitation energy of level (3) in ^{26}Al on 1.055 MeV, and the Q-value of the ^{28}Si$(d, \alpha)^{26}$Al reaction proceeding to it on 0.361 ± 0.007 MeV.

The mass difference between ^{28}Si and ^{26}Mg has been recomputed. Since Li's [15]) evaluation several new accurate Q-values have been measured in this region and Mattauch and Bieri [16]) have increased decisively the accuracy with which d–p, d–α etc. are known. The Q-values used are listed in Table V. The result for the difference of the mass defects is ^{28}Si–^{26}Mg $= -4.689 \pm$ $\pm$ 0.013 MeV, compared to Li's value of -4.688 MeV.

The final result is ^{26}Al*–^{26}Mg $= 4.247 \pm 0.016$ MeV and thus $E_{\beta^+} = 3.225$ $\pm$ 0.016 MeV.

There are two accurate determinations of the half-life of ^{26}Al, viz.: 6.49 ± 0.10 sec [38]) [17]) and 6.68 ± 0.11 sec [39]), giving an average of $6.58 \pm$ $\pm$ 0.10 sec. In this case the external error (0.10 sec) is larger than the internal error (0.07 sec).

In the calculation of the ft value the factor $f(Z, W_0)$ was computed making use of approximations indicated by Feenberg and Trigg [42]). These approximations are very good in this case because of the high W_0 and low Z-value. The "relativistic factor" $R(x, y)$ (using Feenberg and Trigg's

TABLE V

Q-values (in MeV) used in the computation of the ^{28}Si–^{26}Mg difference of mass defects

$^{28}Si(d, p)^{29}Si$	6.246 ± 0.010	Van Patter and Buechner [27])
$^{28}Si(n, \gamma)$ ^{29}Si	8.467 ± 0.008	Kinsey and Bartholomew [28])
$^{29}(Si(d, \alpha)^{27}Al$	5.994 ± 0.011	Van Patter and Buechner [27])
$^{28}Al(\beta^-)^{28}Si^*$ E_β =	2.865 ± 0.010	Motz and Alburger [29])
$^{28}Al(\beta^-)^{28}Si^*$ E_γ =	1.782 ± 0.010	Motz and Alburger [29])
$^{28}Al(\beta^-)^{28}Si^*$ E_β =	2.878 ± 0.014	Olsen and O'Kelley [30])
$^{27}Al(d, p)^{28}Al$	5.494 ± 0.008	Enge et al [31]) [32])
$^{27}Al(n, \gamma)$ ^{28}Al	7.724 ± 0.006	Kinsey and Bartholomew [28])
$^{27}Mg(\beta^-)^{27}Al^*$ E_{β_1} =	1.754 ± 0.011	Daniel and Bothe [33])
$^{27}Al(p, p')^{27}Al^*$	0.843 ± 0.002	Donahue et al [34])
$^{27}Mg(\beta^-)^{27}Al^{**}$ E_{β_2} =	1.592 ± 0.022	Daniel and Bothe [33])
$^{27}Mg(\beta^-)^{27}Al^{**}$ E_{γ_2} =	1.015 ± 0.007	Daniel and Bothe [33])
$^{27}Al(d, \alpha)^{25}Mg$	6.694 ± 0.010	Endt et al [35])
$^{27}Al(p, \alpha)^{24}Mg$	1.594 ± 0.002	Donahue et al [34])
$^{24}Mg(d, p)^{25}Mg$	5.097 ± 0.007	Endt et al [35])
$^{25}Mg(d, p)^{26}Mg$	8.880 ± 0.012	Endt et al [36])
$^{26}Mg(d, p)^{27}Mg$	4.207 ± 0.006	Endt et al [36])
$^{26}Mg(n, \gamma)^{27}Mg$	6.440 ± 0.008	Kinsey and Bartholomew [37])
d—p	6.1443 ± 0.0006	Mattauch and Bieri [16])
n—1	8.3711 ± 0.0021	Mattauch and Bieri [16])
d—α	10.1168 ± 0.0014	Mattauch and Bieri [16])

notation), cannot be obtained accurately enough from their graph, but was found from the NBS tables [43]). The numerical computation was considered correct to 0.1%. All errors made in approximations have been estimated and did not amount to more than 0.2%. No "outer screening correction" has been applied, but it may be considered negligible at this low Z-value [44]).

The final ft value thus obtained is ft = 3200 ± 80 sec.

For allowed transitions the following relation holds:

$$\mathrm{ft}\{|\int 1|^2 + R\,|\int \sigma|^2\} = A,$$

where $R = g_{GT}^2/g_F^2$, $A = 2\pi^3\hbar^7 \log 2/m^5c^4g_F^2$, and where $\int 1$ and $\int \sigma$ are the matrix elements for scalar respectively tensor interaction and g_F and g_{GT} the corresponding coupling constants.

The $0^+ \rightarrow 0^+$ transitions, however, are allowed only by the Fermi selection rule, thus $\int \sigma = 0$. Moreover, $|\int 1|^2$ may be readily calculated [40]) for transitions between states of the same isobaric spin as $|\int 1|^2 = T(T+1) - T_z T_z'$, where T_z and T_z' are the z-components of the isobaric spin T for the initial and final nucleus. For the $0^+ \rightarrow 0^+$ decays in question we have $T = 1$, $T_z = 0$, $T_z' = 1$, yielding $|\int 1|^2 = 2$. Thus the value of g_F may be directly computed from the ft value. The value of ft = 3200 ± 80 sec for $^{26}Al(\beta^+)^{26}Mg$ yields:

$$g_F = (1.391 \pm 0.017) \times 10^{-49}\ \mathrm{erg\ cm^3}.$$

In Table VI this value is compared to that found by Gerhart in the ^{14}O decay and to the one, that may be computed for the ^{34}Cl decay from the data

TABLE VI

List of $0^+ \rightarrow 0^+$ decays				
β^+ transition	t (sec)	E_{β^+} (keV)	ft (sec)	g_F (10^{-49} erg cm^3)
$^{14}O(\beta^+)^{14}N^*$	72.1 ± 0.4 *)	1835 ± 8 *)	3275 ± 75	1.374 ± 0.016
$^{26}Al^*(\beta^+)^{26}Mg$	6.58 ± 0.10 †)	3225 ± 16 °)	3200 ± 80	1.391 ± 0.017
$^{34}Cl(\beta^+)^{34}S$	1.58 ± 0.05 §)	4500 ± 30 !)	3210 ± 140	1.390 ± 0.030
Average:				1.383 ± 0.011

*) Reference 26. †) References 38 and 39. °) Present paper.
§) Reference 1. !) Reference 41.

of Stähelin[1]), and Green and Richardson[41]). The agreement is very satisfactory indeed.

There is known at present one more $0^+ \rightarrow 0^+$ decay between states of the same isobaric spin, viz. $^{10}C(\beta^+)^{10}B$ proceeding in part to the second excited state in ^{10}B. However, the branching ratio is not known accurately enough to warrant the inclusion of this decay in Table VI.

The best average value for g_F from the three decays listed in Table VI is: $g_F = (1.383 \pm 0.011) \times 10^{-49}$ erg cm^3.

*) *Note added in proof.* The radioactivity of the ^{26}Al ground state has now been detected by Simanton, Rightmire, Long and Kohman (to be published in the Physical Review). The half life is $\sim 10^6$ years as computed from estimated reaction cross sections, the β^+ end-point energy is ~ 1 MeV, and a 1.9 MeV γ-ray has been observed. This is in excellent agreement with the predicted properties [5]).

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