proximately

$$C_{1P} = g_P^2 (4M^2)^{-1} (\alpha Z/2\rho)^2 (\alpha Z)^2 \left| \rho^{-1} \int \boldsymbol{\sigma} \cdot \mathbf{r} \right|^2 .$$

As a fair estimate, we consider $|\int \boldsymbol{\sigma}| \approx |\rho^{-1} \int \boldsymbol{\sigma} \cdot \mathbf{r}| \approx |\rho^{-2} \int \mathbf{r}(\boldsymbol{\sigma} \cdot \mathbf{r})|$, where we take for the tensor matrix element the ordinary allowed (not superallowed) value of the matrix element—i.e., we consider all transitions to be subject to the same "unfavored factor." Repeated occurrence of fortuitously extremely small matrix elements is unlikely, as $ft$ values in any group tend to be pretty uniform, and major irregularities here would lead us to expect them elsewhere as well. The presence of a large nuclear force contribution to the pseudoscalar interaction would depress $g_P$ in order to fit of the observed $l$-forbidden $ft$ values. From the ratio $C_{1P}/C_{0T}$ determined from observed $ft$ values for the extensively studied carbon-14[7] and phosphorus-32 and neighboring allowed nuclides, we obtain $|g_P/g_T| \approx 4$ and 20, respectively; the $Z \approx 30$ group yields a ratio near 15. Even a ratio of 20, however, leads to log $ft \approx 8$ for $C_{1P}$ for the highest $Z$—a trifle small to compete equally with the other interactions, and certainly inadequate to account for log $ft \approx 5.5$ among the high-$Z$ $\Delta j = 0$ (yes) group. Thus it appears that the pseudoscalar interaction does not play a detectable role in beta decay, if it is present at all.

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## Ground State of $Al^{26}$

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It has recently been suggested[1,2] that the state in $Al^{26}$, which decays by positron emission with a half-life of 6.7 sec, and which was generally accepted as the ground state, might be the $T_z = 0$ component of the lowest triplet with isobaric spin $T = 1$ and ordinary spin $J = 0^+$. The lowest $T = 0$ state in $Al^{26}$, which might well have an ordinary spin $J = 5^+$,[3] might be situated either above or below the 6.7-second state. In $Li^6$, $B^{10}$, $N^{14}$ and $Na^{22}$ the ground state is a $T = 0$ state, while in $Cl^{34}$ the ground state has $T = 1$. In any case such a low $J = 5^+$ state would have a very long half-life.

There is much conflicting experimental evidence[4–11] about the lowest levels in $Al^{26}$ (see Table I). The differences in the threshold measured by neutron detection and by positron detection both for $Al^{27}(\gamma,n)Al^{26}$ and $Mg^{26}(p,n)Al^{26}$ point to a long-lived state in $Al^{26}$. Moreover, it is found that the neutron yield of the $Al^{27}(\gamma,n)Al^{26}$ reaction is three times larger than the positron yield.[12,1]

In the present investigation the $Mg^{25}(p,\gamma)Al^{26}$ reaction was used to obtain more information on the lowest states in $Al^{26}$. By bombarding thin targets of separated $Mg^{24}$, $Mg^{25}$, and $Mg^{26}$ (obtained from Dr. M. L. Smith, Atomic Energy Research Establishment, Harwell, England) by protons in the energy region from $E_p = 200$ to 700 kev, it was possible to assign six resonances to $Mg^{25}$, *viz.*, at $E_p = 315$, 389, 436, 508 (possibly unresolved doublet), 586, and 620 kev. The first four resonances have been observed previously from natural magnesium targets by Tangen[13] and by Hunt and Jones.[14] Tangen assigned the 436-kev resonance to $Mg^{26}$, as he did not detect positrons at this resonance. Hunt and Jones interpreted also the 315- and 387-kev resonances as $Mg^{26}$ resonances.

TABLE I. Experimental data about the position of the two lowest states in $Al^{26}$ relative to the $Mg^{26}$ ground state.

| Reaction | $Al^{26} - Mg^{26}$ (Mev) | $Al^{26*} - Mg^{26}$ (Mev) | Ref. |
|---|---|---|---|
| $Al^{26}(\beta^+)Mg^{26}$ | | $4.4 \pm 0.5$ | 4, 5 |
| $Al^{26}(\beta^+)Mg^{26}$ | | $(3.8)^a$ | 6 |
| $Al^{26}(\beta^+)Mg^{26}$ | | (4.01) | 7 |
| $Al^{27}(\gamma,n)Al^{26}$ | $3.70 \pm 0.20$ | | 8 |
| $Al^{27}(\gamma,n)Al^{26}$ | | $5.0 \pm 0.4$ | 9 |
| $Mg^{25}(d,n)Al^{26}$ | $2.51 \pm 0.10$ | $4.51 \pm 0.18$ | 10 |
| $Mg^{26}(p,n)Al^{26}$ | $\sim 2.6$ | (4.3) | 11 |

[a] The value has been put between parentheses, when the isotopic assignment is doubtful.

Gamma-ray energies were measured with a scintillation spectrometer ($2 \times 2 \times 3$ cm$^3$ NaI crystal). Pulses were fed both to a one-channel differential discriminator and to an ordinary discriminator, used as a monitor. Energy calibrations were performed with a Po-Be source ($E_\gamma = 4.44$ Mev) and with $\gamma$ rays from the $F^{19}(p,\alpha\gamma)O^{16}$ reaction ($E_\gamma = 6.13$ Mev) and from the $C^{13}(p,\gamma)N^{14}$ reaction ($E_\gamma = 8.06$ Mev).

At the 436-kev resonance a $\gamma$ ray of $E_\gamma = 6.77 \pm 0.08$ Mev is observed indicating an $Al^{26}$ state (the ground state) $3.96 \pm 0.08$ Mev above the $Mg^{26}$ ground state. At all resonances a $\gamma$ ray was found proceeding to an $Al^{26}$ level $4.42 \pm 0.08$ Mev above the $Mg^{26}$ ground state, corresponding to $0.46 \pm 0.08$ Mev above the $Al^{26}$ ground state (see Table II). No higher energy $\gamma$ rays were found at any of the six resonances investigated. There are certainly present several lower energy $\gamma$ rays, but their energy has not yet been accurately determined. In a preliminary survey positrons from the $Al^{26}$ decay were observed at all of the investigated resonances. However at the 436-kev resonance the yield is certainly low, in agreement with Tangen's observation.[13]

TABLE II. Observed $\gamma$ rays at six $Mg^{25}(p,\gamma)Al^{26}$ resonances.

| Resonance proton energy (kev) | $E\gamma_1$ (Mev) | $Mg^{25} + p - Al^{26}$ (Mev) | Rel.[a] int. | $E\gamma_2$ (Mev) | $Mg^{25} + p - Al^{26*}$ (Mev) | Rel.[a] int. |
|---|---|---|---|---|---|---|
| 315 | | | $\leq 3$ | 6.28 | 5.98 | 18 |
| 389 | | | $\leq 2$ | 6.20 | 5.83 | 8 |
| 436 | 6.77 | 6.35 | $\geq 25$ | 6.28 | 5.86 | 6 |
| 508 | | | $\leq 2$ | 6.38 | 5.89 | 10 |
| 586 | | | $\leq 2$ | 6.43 | 5.87 | 18 |
| 620 | | | $\leq 2$ | 6.50 | 5.90 | 19 |

[a] The relative intensity is given in percents of the number of $\gamma$-ray pulses larger than 1 Mev.

All experimental evidence cited in this letter is compatible with the assumption that the $Al^{26}$ ground state has isobaric spin $T = 0$ and the level at 0.46 Mev $T = 1$. If the ground state really has a spin $J = 5^+$, it probably decays by a second forbidden $\beta^+$ transition to the $Mg^{26}$ level at 1.83 Mev (assumedly with $J = 2^+$) with a $\beta^+$ endpoint of $1.11 \pm 0.08$ Mev. Taking log $ft = 13.0$ leads to an estimated half-life of $4 \times 10^4$ years.

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## Proton-Proton Scattering from 40 to 95 Mev*

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Proton-proton scattering has been studied with the external beam of the Harvard cyclotron, using scintillation counters to detect the protons scattered from hydrocarbon targets