The existence of T_x and T_s was investigated in an independent set of experiments which also confirmed the known positive moment of P^{31} and established a negative moment for P^{32}. The T_x under discussion occurs only in the presence of exchange lines and corresponds therefore to a different mechanism than the one discussed by Pines, Bardeen, and Slichter.[8] It presumably arises from the fact that some exchange lines have transition frequencies identical to the ones required for the T_x transition. It is of interest to note that the situation depicted in Fig. 3 which is similar to the one described by Pines *et al.*[8] provides a convenient way of polarizing the P^{32} nuclei.

According to the shell model,[9] the odd proton is in a $2s_{\frac{1}{2}}$ and the odd neutron in a $3d_{\frac{3}{2}}$ state. Assuming jj coupling and taking the Schmidt-line limits for g_p and g_n, one predicts a moment of $\mu=-0.44$ nm. Taking the empirically found g values[7] of the odd-even and even-odd neighbors, i.e., $g_n=0.4289$ ($_{16}S_{17}{}^{33}$) and $g_p=2.263$ ($_{15}P_{16}{}^{31}$), one predicts a moment of $\mu=-0.03$ nm. The spin value of 1 is consistent with Nordheim's[10] "strong" coupling rule.

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Experimental μ^--Capture Rates: Evidence on Exclusion Principle Effects and the Type of Interaction*

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VARIOUS scattered measurements of μ^--capture rates[1] have so far brought out two features: (1) approximate validity of the $Z_{eff}{}^4$-law,[2] and (2) approximate equality of the strength of the responsible four-fermion interaction with that of β decay ("restricted universality"). Other features, such as (3) dependence on specific nuclear properties (shell structure, etc.), and (4) the specific form of the interaction (Fermi and/or Gamow-Teller), cannot be discerned from the existing data, often of limited accuracy.

In view of this situation, we have undertaken a program of accurate μ-disappearance rate measurements. In our experiments, a 99% pure μ^- beam[3] is stopped in different targets (6–10 g/cm^2), and the stopped muons as well as the decay electrons are counted with coincidence telescopes. Suitable anticoincidences guarantee that the μ^-'s stop in, and the e^- emerge from, the target. The disappearance rates are measured directly by means of delay-to-pulse-height converters[4] fed by the outputs of the μ^- and e^- telescopes; the data are collected in a 100-channel pulse-sorter. The over-all linearity of the system is frequently checked with a precision lumped constant delay line, using real pulses.

Table I contains the results obtained to date. Except where otherwise indicated, elemental targets of high purity were used. At least 3×10^4 significant counts were collected for each target; the background (mainly accidentals) contributed always $\leq 10\%$ to this number. The converter ranges were so chosen (≥ 3 lifetimes) as to facilitate the determination of this contribution. For elemental targets, Peierls' method[5] was used to compute lifetimes; as a check on our absolute time scale, a determination of the μ^+ mean life (in graphite) was made, yielding (2.21 ± 0.02) μsec which agrees with the currently accepted value.[6]

TABLE I. Comparison of capture rates measured in this experiment with Primakoff's theoretical predictions.

Element[a]	Z_{eff} used[b]	Λ_{capt} (10^5 sec^{-1}) This exp.	Theoretical[c]
Be	3.93	0.28 ± 0.10	0.063
C	5.78	0.43 ± 0.10	0.45
N	6.68	0.93 ± 0.12	0.80
O(H_2)	7.56	1.38 ± 0.12	1.31
F(KH)$_{\frac{1}{2}}$	8.40	2.54 ± 0.22	1.68
Na	10.02	3.76 ± 0.21	3.54
Mg	10.83	4.86 ± 0.48	5.37
Al	11.58	7.85 ± 0.44	6.60
Si	12.31	8.31 ± 0.65	9.14
P	13.02	10.40 ± 0.75	10.5
S	13.7	13.7 ± 0.9	14.0
Cl(Na)	14.4	13.8 ± 0.9	15.0
K(HF_2)	15.6	19.9 ± 1.2	21.7
Ca	16.2	25.1 ± 0.9	27.8
Ti	17.4	25.8 ± 0.8	27.8
V	17.9	33.4 ± 0.8	29.2
Cr	18.4	31.7 ± 1.1	35.3
Mn	18.9	37.3 ± 1.2	37.4
Fe	19.4	44.9 ± 1.5	45.0
Ni	20.3	58.8 ± 1.9	58.6
Cu	20.7	67.9 ± 2.2	54.5
Ag	26.2	104.3 ± 5.5	116
Cd	26.5	101 ± 5.2	110
Tl	31.3		150
Pb	31.4	125 ± 6.5 (Tl, Pb, Bi)	146
Bi	31.5		151
U	32.1	91.8 ± 6.0	135

[a] Other constituents are indicated in parentheses where target was a compound.
[b] See reference 2.
[c] See reference 7.

TABLE II. Comparison of ratios of capture rates obtained in this experiment with Tolhoek and Luyten's predictions.

Elem. ratio	Theoretical values[a,b] for natural isotope mixture (S,V)	(T,A)	This experiment
Cr/Ca	0.90	1.28	1.26±0.07
Fe/Ca	1.08	1.70	1.79±0.09
Ni/Ca	1.34	2.21	2.34±0.12
V/Ca	0.77	1.03	1.33±0.10
Fe/Ti	1.23	1.68	1.74±0.10
Mn/Ca	0.95	1.43	1.48±0.08

[a] See reference 8.
[b] Using $r_0=1.40\times10^{-13}$ cm.

Primakoff has predicted[7] nuclear capture rates, $\Lambda_{\text{capt}}(A,Z)$, using the closure approximation. To order A^{-1}, his rates are independent of the specific type of interaction, and are given by

$$\Lambda_{\text{capt}}(A,Z)=\Lambda_{\text{capt}}(1,1)Z_{\text{eff}}^4\gamma\left[1-\frac{A-Z}{2A}\delta\right]. \quad (1)$$

The last bracket arises from the Pauli principle; δ is a correlation parameter, estimated to be ≈ 3. The quantity γ corrects for the reduction in the neutrino phase-space volume due to the absorption of the μ^- by a *bound* proton; Primokoff estimated $\gamma\approx 0.73$, and derived the value of $\Lambda_{\text{capt}}(1,1)$, as yet unknown experimentally, from β-decay data by assuming "restricted universality." This yields $\Lambda_{\text{capt}}(1,1)=220$ sec^{-1}.

In Table I the Λ_{capt} calculated from (1) with Primakoff's parameters are also given. They are, on the whole, in excellent accord with experiment; the best fit is obtained with $\delta=3.06$, $\Lambda_{\text{capt}}(1,1)\gamma=177$ sec^{-1}. Retaining $\gamma=0.73$, one obtains $\Lambda_{\text{capt}}(1,1)=(240\pm15)$ sec^{-1}, a result suggesting *exact* equality of interaction strengths.

Tolhoek and Luyten[8] have recently argued, on the basis of explicit shell model calculations in which only the "dominant" transitions are retained, that the relative capture rates of nuclides in the range Ca–Ni depend sensitively on the nature of the interaction, i.e., on whether the latter is of the (S,V) or the (T,A) type. Table II is a comparison of our results with the predictions of reference 8; it would appear that the interaction is predominantly of (T,A) character. The strength of this conclusion is impaired by the excellent agreement of Primakoff's interaction-independent theory with experiment.

A full account of the present work is being prepared for this Journal. We are also planning similar measurements with separated isotopes of light elements.

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Re-Establishment of μ^+ Polarization in Depolarizing Media by an External Magnetic Field*†

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RECENT investigations[1–3] of the decay of longitudinally polarized μ^+ mesons at rest have revealed that the angular distribution of the decay positrons varies greatly, for a fixed polarization of the initial μ^+ beam, with the material in which the muons are stopped. This fact is attributed to the depolarizing effects of some microscopic magnetic fields acting (in materials yielding reduced asymmetry) on the muon spin. The results of experiments in this Laboratory[2] and at Liverpool[3] imply further that these effects operate in time short compared to 10^{-6} sec. In muonium (μ^+e^-), as well as in other systems in which the muon spin is coupled to another spin, the "hyperfine" interaction provides a fast depolarization mechanism that can account for the observed effects.[4]

It is well known that the angular correlation of successive nuclear radiations can be perturbed by hyperfine interactions; Goertzel[5] has proposed to reduce such perturbations by decoupling the nuclear spin from the angular momentum of the shell by an external magnetic field applied along the "axis of polarization" of the nucleus. The application of this idea to experiments with muons is obvious; it serves the twofold purpose of elucidating the nature of the depolarizing mechanism, and of making—if successful—certain depolarizing media (such as nuclear emulsion[6] or pentane[2]) more useful tools in this field.

Figure 1 shows a schematic diagram of the equipment used in such a "repolarization" experiment. A $\pi^+-\mu^+$ beam of momentum 145 Mev/c, containing 10% μ^+ mesons, traverses scintillator 1, enters a solenoid S axially, and is freed of π's by an absorber-plug P. After passing through scintillators 2 and 3, muons are brought to rest in a target T, consisting of the material under investigation and tightly sandwiched between 2, 3, and two further scintillators 4 and 5. T as well as 2, 3, 4, and 5 are contained in a 2-in. wide gap that effectively divides S into two halves; the scintillators are coupled