Table I. X-ray quantum limit determinations.

Experiment	Nominal voltage (volts)	Resolution[a] (volts)	Discrepancy (volts) old	Discrepancy (volts) new
BS[b]	8050	0.75	-1.4	+1.5
BS[b]	19600	1.7	-3.4	-1.4
BJW[c]	6112	0.55	-0.7	+0.4
BJW[c]	10168	0.95	-0.8	+0.4
		Sum of discrepancies	-6.3	+0.9
FHD[d]	24500	12	-4.3	+3.4

[a]Full half-width.
[b]J. A. Bearden and G. Schwarz, Phys. Rev. 79, 674 (1950).
[c]Bearden, Johnson, and Watts, Phys. Rev. 81, 70 (1951).
[d]Felt, Harris, and DuMond, Phys. Rev. 92, 1160 (1953).

of the measurements. Due to the bad resolution, the newest investigation in the lowest line does not fulfill our second assumption and therefore is not taken into account. It should be mentioned that values of the last column contain also a small correction for the mean velocity of the emitted electrons as first recognized by Bearden and Thomsen.[5]

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THEORY OF THE VECTOR INTERACTION WITH A CONSERVED CURRENT AND THE BETA DECAY OF Na^{24}-Al^{24} NUCLEI

Claude C. Bouchiat
Palmer Physical Laboratory, Princeton University, Princeton, New Jersey
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In the theory of the vector interaction with a conserved current the observed deviations from the $\Delta T=0$ selection rule in Fermi transitions have to be explained only in terms of isotopic spin impurities.[1] However, in the conventional theory exchange mesonic currents may also induce Fermi transitions with $\Delta T \neq 0$. Recently an attempt[2] has been made to estimate the contribution of isotopic spin impurities introduced by the Coulomb interaction between the protons. The relevant Coulomb matrix elements have been calculated with the wave functions given by the j-j coupling shell model. A comparison between the calculated Fermi matrix element and the experimental one was performed in the case of the β^- decay of the $T=1$, $J=4^+$ state of Na^{24} to the state $T=0$, $J=4^+$ of Mg^{24}. The experiments[3] on Na^{24} agree only with a value of M_F smaller than 10^{-3} while the theoretical estimate yields a value of about 1.3×10^{-2}. The two following interpretations are possible: (a) By using j-j coupling shell model wave functions the Coulomb matrix element has been overestimated; (b) exchange mesonic currents do induce Fermi transitions, and a cancellation occurs between the Coulomb term and the mesonic term. In this note we discuss a possible experiment which would enable us to make a choice between these two possibilities without having to use any nuclear model.

Let us consider the $T=1$ multiplet which consists of the ground states of Al^{24} and Na^{24} and of the 9.5-Mev level of Mg^{24}. The β^+ decay of the ground state of Na^{24} has a 99.9% branch to the $T=0$, $J=4^+$ level of Mg^{24} and the β^- decay of Al^{24} has a 10% branch to the same level. The Fermi matrix element for these two transitions is given by

$$M_F^{\pm}=\langle\alpha_f\; T=T_\zeta=0\,|\,\mathcal{H}_F^{\mp}\,|\,\alpha_i\; T=1\; T_\zeta=\pm1\rangle$$
$$+a_0(1)\langle\alpha_i\; T=1\; T_\zeta=0\,|\,\mathcal{H}_F^{\mp}\,|\,\alpha_i\; T=1\; T_\zeta=\pm1\rangle. \quad (1)$$

In this formula $\pm$ refers to $\beta^{\mp}$ decay. The operator $\mathcal{H}_F^{\mp}$ which describes the Fermi transition is given in the conventional theory by

$$\mathcal{H}_F^{\pm}=(C_V^0/C_V)\,\tau^{\pm}=(C_V^0/C_V)\int d^3x\,\bar{\psi}\,\tau_{\pm}\psi, \quad (2)$$

where C_V^0 is the bare coupling constant and C_V the renormalized one.

In the theory with a conserved current, we have

$$\mathcal{H}_F^{\pm}=T^{\pm}=\tau^{\pm}+\mathcal{R}^{\pm}=\tau^{\pm}+i\int\left(\phi^*\rho_{\pm}\frac{\partial\phi}{\partial t}-\frac{\partial\phi^*}{\partial t}\rho_{\pm}\phi\right)d^3x. \quad (3)$$

The operators $T^{\mp}, \tau^{\mp}, \mathcal{R}^{\mp}$ are, respectively, the total isotopic spin operator, the nucleon isotopic operator, and the π-meson isotopic spin operator. The indices α_f, α_i represent the set of quantum numbers characterizing the initial and final states in the absence of a charge-dependent perturbation. The quantity $a_0(1)$ is the amplitude of the state $|\alpha_i\; T=1\; T_\zeta=0\rangle$ which is mixed to the state $|\alpha_f\; T=0\; T_\zeta=0\rangle$ under the influence of the charge-dependent perturbation. Now we apply the Eckart-Wigner theorem to the isotopic vector operator $\mathcal{H}_F^{\mp}$. We obtain

$$M_F^{\pm}=\pm\langle T=0\,\|\,\mathcal{H}_F\,\|\,T=1\rangle+a_0(1)\langle T=1\,\|\,\mathcal{H}_F\,\|\,T=1\rangle. \quad (4)$$

Inserting into the above formula the expression for $\mathcal{H}_F$, we get in the conserved current theory

$$M_F^{\pm}=a_0(1)\sqrt{2}, \quad (5)$$

and in the conventional theory

$$M_F^{\pm}=\mp(C_V^0/C_V)\langle T=0\,\|\,\mathcal{R}\,\|\,T=1\rangle+a_0(1)\sqrt{2}. \quad (6)$$

In the formula (6) we have replaced $(C_V^0/C_V)\times\langle T=1\,|\,\tau^{\pm}\,|\,T=1\rangle$ by $\sqrt{2}$, which means that we neglect possible exchange effects in the $\Delta T=0$ matrix element. This is quite legitimate since we know from the ft values of $0^+\to0^+$ transitions that the Fermi matrix element does not differ from $\sqrt{2}$ by more than a few percent.

Let us now discuss the angular distribution of the polarized γ ray of Mg^{24*} relative to the direction of emission of the $\beta^{\mp}$ particle:

$$W^{\pm}(\theta)d(\cos\theta)=[1+(v/c)\tau A^{\pm}\cos\theta]d(\cos\theta), \quad (7)$$

where $\tau=\pm1$ stands for right (left) circular polarization. The anisotropy coefficient A is given by

$$A^{\pm}=\tfrac{1}{3}[\pm\tfrac{1}{4}+(\sqrt{5})y^{\pm}]\frac{1}{1+(y^{\pm})^2}, \quad (8)$$

with

$$y^{\pm}=|(C_V/C_A)|(M_F^{\pm}/M_{GT}^{\pm}).$$

A formula similar to (4) is valid for $M_{GT}^{\pm}$:

$$M_{GT}^{\pm}=\pm\langle\alpha_f\; T=0\,\|\,\vec{\mathcal{H}}_{GT}\,\|\,\alpha_i\; T=1\rangle$$
$$+a_0(1)\langle\alpha_i\; T=1\,\|\,\vec{\mathcal{H}}_{GT}\,\|\,\alpha_i\; T=1\rangle, \quad (9)$$

where

$$\vec{\mathcal{H}}_{GT}=\int d^3x\,\bar{\psi}\beta\vec{\sigma}\psi.$$

The matrix element $\langle\alpha_i\; T=1\,\|\,\vec{\mathcal{H}}_{GT}\,\|\,\alpha_i\; T=1\rangle$ has been estimated by Bolsterli and Feenberg[4] to be about 0.15. From the ft value of Na^{24} we know that $\langle\alpha_f\; T=0\,\|\,\vec{\mathcal{H}}_{GT}\,\|\,\alpha_i\; T=1\rangle$ is of the order of 0.06. So even if $a_0(1)$ is taken equal to the calculated value 0.009, we may neglect the second term in the formula (9) and use for

$$\langle\alpha_f\; T=0\,|\,\vec{\mathcal{H}}_{GT}\,|\,\alpha_i\; T=1\rangle$$

the value deduced from the ft value of Na^{24}. Using the formula (5) we see that if the theory of the vector interaction with a conserved current is the correct one the following equation holds:

$$A^{(+)}+A^{(-)}=0. \quad (10)$$

As a test of the theory of the vector interaction with a conserved current we suggest the repetition on Al^{24} of the experiment already done on Na^{24} by several groups. If the relation (10) happens to be true we predict for Al^{24} an anisotropy coefficient $A^{(-)}$ close to the pure Gamow-Teller value, namely, $A^{(-)} = -0.08$. Such a result would also imply that the theoretical estimate of $a_0(1)$ was incorrect. But if the interpretation (b) is the right one a very different value for $A^{(-)}$ will be found. In that case we assume that the calculated value for $a_0(1)$ is correct and that a mesonic term exists which cancels amost exactly the Coulomb term [Eq. (6)]. We will find for the anisotropy coefficient $A^{(-)}$ the two following values depending on the sign of the ratio $a_0(1)/M_{GT}^{(+)}$ (a j-j coupling calculation suggests a positive sign):

$$A^{(-)} = -0.32, \quad [a_0(1)/M_{GT}^{(+)}] > 0,$$

$$A^{(-)} = 0.17, \quad [a_0(1)/M_{GT}^{(+)}] < 0. \qquad (11)$$

We would like to add a final remark concerning the validity of the formulas (7) and (8). Since the $\beta^{(+)}$ decay branch of Al^{24} we are considering is a high-energy branch ($E_{max} \simeq 9.5$ Mev) with a large ft value ($\log ft \simeq 6.1$), the forbidden correction may not be completely negligible. However, we have made an estimate of these corrections and we have found that they are negligible compared to the experimental errors in the measurement of the circular polarization of the γ ray.

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SEARCH FOR Li^{4}†

S. Bashkin,* R. W. Kavanagh, and P. D. Parker
Kellogg Radiation Laboratory, California Institute of Technology, Pasadena, California
(Received November 2, 1959)

The possibility that Li^4 might be stable against decay into He^3 and a proton has led to revived speculation[1] concerning the effect which such a nucleus would have in stellar processes. Although there are good theoretical and some experimental arguments[1,2] against the existence of a β-active Li^4, it seemed important to make a direct, experimental investigation of this nucleus. Li^4, if just particle-stable, would be converted into He^4 by emitting a positron with an end-point energy near 19 Mev. The mean life of Li^4 may be estimated from calculations[3] on the decay of the mirror nucleus, H^4, to be in the neighborhood of 30 milliseconds. Consequently, it was decided to try to produce Li^4 in the reaction $He^3(p,\gamma)Li^4$, and to detect the residual nucleus by counting the delayed positrons from $Li^4(\beta^+\nu)He^4$.

Figure 1 illustrates the target arrangement.

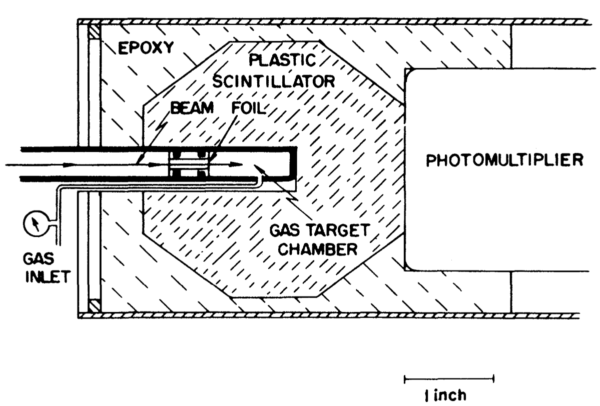

FIG. 1. Target arrangement.

Either He^3 (90% pure) or He^4 (assumed 100% pure) served as the target gas at an absolute pressure of 25 psi. Protons were accelerated to