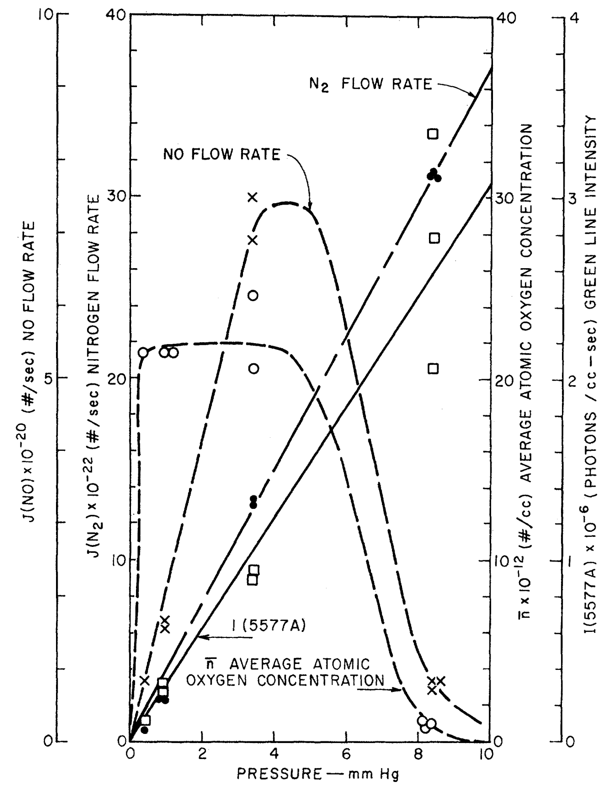

FIG. 1. Experimental results showing that $I(5577A)$ does not vary as $\bar{n}^3$. All ordinates are in absolute units.

atomic oxygen concentration. The Chapman reaction (1), if present, could excite at most only 10% of the observed emission. At a pressure of 0.4 mm Hg we have $\bar{n} = 2 \times 10^{13}$ atoms/cc, while the upper limit of the 5577A flux attributable to the Chapman reaction is 1.5×10^4 photons/cc sec. Therefore the rate coefficient is less than 2×10^{-36} cc^2/sec, which is insufficient by two orders of magnitude for producing the observed airglow intensity.

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[1]S. Chapman, Proc. Roy. Soc. (London) A132, 353 (1931).

[2]F. E. Roach, J. W. McCaulley, E. Marovich, and C. M. Purdy, J. Geophys. Research 65, 1503 (1960).

[3]E. Tandberg-Hanssen and F. E. Roach, J. Research Natl. Bur. Standards 63D, 319 (1959).

[4]J. F. Noxon, thesis, Harvard University, 1957 (unpublished).

[5]This particular technique was suggested by C. A. Barth.

[6]J. E. Blamont and A. Kastler, Ann. géophys. 7, 73 (1951); F. E. Roach and H. Pettit, J. Geophys. Research 56, 325 (1951).

[7]R. A. Young, J. Opt. Soc. Am. 50, 627 (1960).

[8]G. B. Kistiakowsky and G. G. Volpi, J. Chem. Phys. 28, 665 (1958).

[9]S. Krongelb and M. W. P. Strandberg, J. Chem. Phys. 31, 1196 (1959).

COMPARISON OF THE β-α ANGULAR CORRELATIONS IN Li^8 AND B^8 †

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Although the radiations following allowed β decay of unoriented nuclei are uncorrelated in angle with the β rays, forbidden effects may produce correlations of the form $1 + B\cos^2\theta$, where the small coefficient B depends on the details of the matrix elements involved. As a possible test of the conserved vector current (C.V.C.) theory,[1] various authors[2,3] have suggested a measurement of the difference, δ, of the B coefficients in the β-α correlations of the two decays: $Li^8(\beta\bar{\nu})Be^{8*}(\alpha)He^4$ and $B^8(\bar{\beta}\nu)Be^{8*}(\alpha)He^4$. Assuming an average strength for the relevant $M1$ matrix element, Bernstein and Lewis[2] predicted $\delta = 0.015W_\beta$, where W_β is in Mev and we neglect m_0^2/W_β^2. Our preliminary result,[4] $\delta \cong (0.003 \pm 0.004)W_\beta$, conflicted with this prediction and indicated either the failure of the C.V.C. theory or that the value assumed for the $M1$ matrix element was too large. Since our preliminary measurements, the $M1$ matrix element has been calculated on an intermediate-coupling model.[5,6] Weidenmüller's calculations[6] predict $0.005W_\beta \leq \delta \leq 0.009W_\beta$ on the basis of the C.V.C. theory, or a similar but smaller effect, $0.001W_\beta \leq \delta \leq 0.004W_\beta$ on the basis of the Fermi theory. In view of these calculations we have remeasured δ with improved statistical accuracy and with special emphasis on reducing systematic errors, and we find $\delta = (0.0069 \pm 0.0008)W_\beta$, in agreement with the C.V.C. theory.

Neglecting smaller terms, the β-α angular correlation in the laboratory is of the form $W(\theta) = 1 + A\cos\theta + B\cos^2\theta$. The coefficient A arises from the transformation from Be^{8*} to laboratory coordinates because of the recoil of Be^{8*} from the β decay; it may have small contributions from various forbidden vector and axial-vector matrix elements. To first order in P_β/P_α, neglecting forbidden terms,[7] $A = -P_\beta/P_\alpha \cong -0.0093W_\beta$. The values for A measured in the present experiment are slightly smaller:

$$A(\mathrm{Li}^8) = -(0.0087 \pm 0.0002)W_\beta,$$

$$A(\mathrm{B}^8) = -(0.0088 \pm 0.0005)W_\beta.$$

The difference $\delta = B(\mathrm{Li}^8) - B(\mathrm{B}^8)$ arises from the small forbidden vector matrix elements of the β decay. As shown by Weidenmüller,[6] considering only the $M1$ matrix element:

$$\delta \propto (P_\beta^{\,2}/W_\beta)\frac{\langle \| l \| \rangle + \langle \| \sigma \| \rangle}{\langle \| \sigma \| \rangle},$$

$0.001W_\beta \leq \delta \leq 0.004W_\beta$ for the Fermi theory;

$$\delta \propto (P_\beta^{\,2}/W_\beta)\frac{\langle \| l \| \rangle + 4.7\langle \| \sigma \| \rangle}{\langle \| \sigma \| \rangle},$$

$0.005W_\beta \leq \delta \leq 0.009W_\beta$ for the C.V.C. theory. Other second-forbidden vector matrix elements which could contribute to δ, such as the $E2$, are predicted to be at least an order of magnitude smaller. With an average β energy of 11 Mev the measured values for B are

$$B(\mathrm{Li}^8) = (0.0029 \pm 0.0003)W_\beta,$$

$$B(\mathrm{B}^8) = -(0.0040 \pm 0.0007)W_\beta,$$

$$\delta = (0.0069 \pm 0.0008)W_\beta,$$

where the standard deviations quoted are statistical in origin only. The less precise values of our earlier experiment,[4] $B(\mathrm{Li}^8) = (0.003 \pm 0.002)W_\beta$ and $B(\mathrm{B}^8) = (0.000 \pm 0.004)W_\beta$, are consistent with these new measurements. The recent work of Krebs et al.[8] gives $B(\mathrm{Li}^8) = (0.0054^{+0.0027}_{-0.0017})W_\beta$ at $W_\beta = 7.5$ Mev.

The apparatus and techniques of this experiment were similar to those of the previous one[4] but improved in several important ways to reduce and check systematic errors. The angle of the target to the beam was changed from 45° to 15° (see insert in Fig. 1) in order to minimize the depth of recoil of B^8 nuclei into the target backing. Previously, this recoil had produced a loss in energy of the α particles in escaping from the target which was much more severe

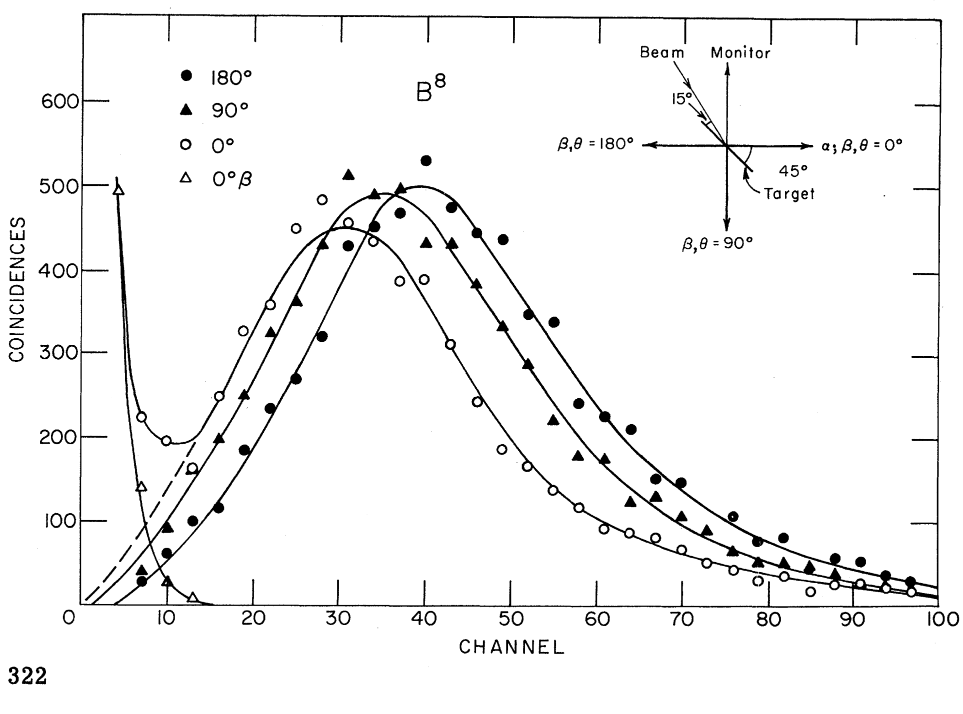

FIG. 1. Pulse-height spectra of α particles coincident with β rays at 0°, 90°, 180°, following the β decay of B^8. The low-energy end of the $\theta = 0°$ spectrum is extrapolated by subtracting β-β coincidences (curve marked 0° β) as explained in the text.

for B^8 than for Li^8. During bombardment, a shield around the target protected the α counter from any sputtered target material and from any recoiling B^8 or Li^8 ions which left the target. The spectra of α particles from the Be^{8*} coincident with β rays from the B^8 were much improved by these changes, as compared with the earlier experiment, and were in fact very similar to the Li^8 spectra. Figure 1 shows the B^8 α spectra for a typical case.

New α counters, thin to β rays, permitted measurements to be made when the angle between the α momentum and the β momentum was $\theta = 0°$ as well as 90° and 180°. However, at $\theta = 0°$, a small fraction of the β rays going through the α counter and into the β counter, produced small pulses in the α counter in coincidence with the β counter. For this reason the low-energy tail of the $\theta = 0°$ coincident α spectrum was extrapolated by subtracting these β-β coincidences, as determined by stopping all the α particles from the target. (See Fig. 1.) Errors produced by this extrapolation would be expected to be in the same direction for both $B(Li^8)$ and $B(B^8)$, and tend to cancel in the difference δ. To estimate the possible magnitude of this error, we have also determined δ by analyzing only the $\theta = 90°$ and 180° data and find δ decreased by $0.0002W_\beta$.

The lithium targets were evaporated in a narrow 2-mm wide vertical strip on the thin aluminum backing to minimize changes in geometry due to lateral motion of the incoming beam. A check for motion of the target spot relative to the α counter was also made with a monitor counter. From the ratio of monitor counts to noncoincident α counts, we conclude that the α-counter solid angle was constant to within 0.002, which when divided by the average β energy, $\overline{W}_\beta \cong 11$ Mev, represents an uncertainty of $0.0002W_\beta$ in δ. The determination of $\overline{W}_\beta$ could be in error by ~5%, which would produce an error in δ of $\sim 0.0004W_\beta$. We estimate the systematic error from all these sources to be less than $0.001W_\beta$ in δ.

Including the statistical and estimated systematic errors, our experimentally determined value for δ lies within the range predicted by the C.V.C. theory based upon intermediate-coupling calculations. An experimental determination of the relevant $M1$ and $E2$ matrix elements is desirable, as a check on the theoretical estimates.

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[1]R. P. Feynman and M. Gell-Mann, Phys. Rev. 109, 193 (1958); M. Gell-Mann, Phys. Rev. 111, 362 (1958).
[2]J. Bernstein and R. R. Lewis, Phys. Rev. 112, 232 (1958).
[3]M. Morita, Phys. Rev. 113, 1584 (1959).
[4]M. E. Nordberg, B. Povh, and C. A. Barnes, Phys. Rev. Letters 4, 23 (1960).
[5]D. Kurath, Phys. Rev. Letters 4, 180 (1960).
[6]Hans A. Weidenmüller, Phys. Rev. Letters 4, 299 (1960).
[7]B. Stech and J. Eichler (private communication).
[8]K. Krebs, H. Rieseberg, and V. Soergel, Z. Physik 159, 232 (1960).

ft VALUE OF O^{14} AND THE UNIVERSAL FERMI INTERACTION*

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The experimentally observed near equality of the coupling constants in the nuclear beta-decay and in muon decay has suggested the attractive idea that all of the "weak interactions" proceed by a universal Fermi interaction.[1] The fact that the coupling constant in nuclear beta-decay is not considerably decreased by virtue of the neutron or proton existing part of the time as a proton or neutron plus pion cloud finds an elegant explanation in the conserved vector current hypothesis of Feynman and Gell-Mann.[1,2] It is thus of considerable interest to establish the degree to which the coupling constants G_V for the vector nuclear beta decay and G_μ for the muon decay are equal.[3-5] Recently the precision with which G_μ is known has improved considerably due to