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.

We are indebted to Professor Treiman for a valuable criticism. We wish to express our appreciation to Professor Wigner for his encouragement and for reading the manuscript. We want also to acknowledge helpful discussions with Dr. Henry Hill and Professor Sherr about the feasibility of the experiment.

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SEARCH FOR Li^4†

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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.

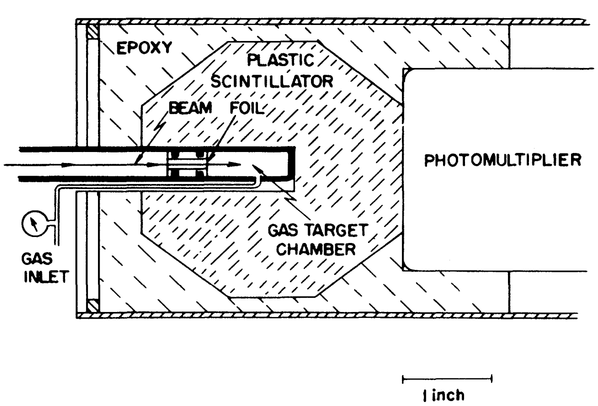

FIG. 1. Target arrangement.

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 an energy of 1.37 Mev. The entrance foil was 160 kev thick and the gas target 140 kev thick, so that the protons interacted with the He^3 with a mean energy of 1.14 Mev or $E_{c.m.} = 855$ kev. The responses of the heavily shielded scintillator to cosmic rays, 6-Mev gamma rays from $F^{19}(p, \alpha\gamma)O^{16}$, pairs from $F^{19}(p, \alpha\pi)O^{16}$, 2.62-Mev gamma rays from ThC′′ and betas from $B^{11}(d,p)B^{12}(\beta\nu)C^{12}$ were determined, and the detector and scalers biased to give an over-all detection efficiency of 80% for the positrons expected from Li^4.

An electromagnet, operated at 60 cps, swept the proton beam past a narrow slit, allowing a beam pulse as shown in Fig. 2 to strike the target. Two scalers, together comprising a single-channel analyzer spanning the appropriate pulse heights, were gated to count while the beam was off, as illustrated in Fig. 2. It was found that the number of counts was independent of the target gas, and came from machine background and cosmic rays. With the chopping cycle of Fig. 2, a total of 2745 counts was recorded in 7×10^5 cycles with He^3 in the target chamber. The total charge collected was 6800 microcoulombs. After subtraction of the background counts, which were identical within statistics to the above number, an upper limit may be placed on the cross section for formation of Li^4. That limit depends on the assumed mean life. For data taken in the described manner, one may write

$$N = N_0 N_1 \epsilon \sigma F(\lambda) B(t_1),$$

where N = total number of counts (N_{He^3}) corrected for background (N_{He^4}),

$$N = N_{He^3} - N_{He^4} \pm (N_{He^3} + N_{He^4})^{1/2} \lesssim (N_{He^3} + N_{He^4})^{1/2}.$$

N_0 = number of target nuclei per cm^2; N_1 = number of incident protons; ϵ = over-all detection efficiency; σ = cross section; λ = disintegration constant;

$$F(\lambda) = \frac{e^{\lambda t_1}(e^{-\lambda t_2} - e^{-\lambda t_3})}{\lambda t_1} \frac{(1 - e^{-\lambda t_1})}{(1 - e^{-\lambda t_4})} \left[1 - \frac{1 - e^{-m\lambda t_4}}{m(e^{\lambda t_4} - 1)}\right],$$

where m = number of cycles; t_1, t_2, t_3, t_4 are defined in Fig. 2, and

$$B(t_1) = \text{beam factor} = [1 + (\lambda t_1 / 2\pi)^2]^{-1}.$$

With these expressions and the measurements on N, N_0, N_1, ϵ, and $B(t_1)$, it is possible to calculate an upper limit for σ as a function of $\tau = 1/\lambda$. The results are not very sensitive to the beam shape, and the assumed beam factor is based on a sinusoidal approximation to the beam pulse. The results are shown in Fig. 3; for a mean life in the range 0.006 to 600 seconds, the cross section is $\lesssim 4 \times 10^{-11}$ barn.

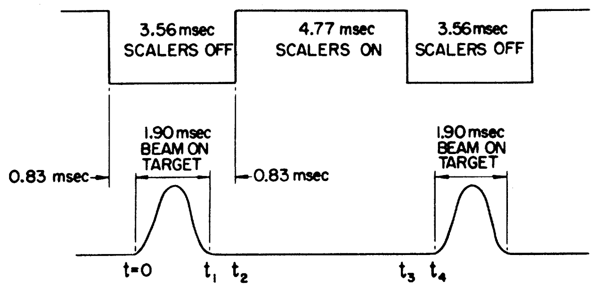

FIG. 2. Chopping cycle.

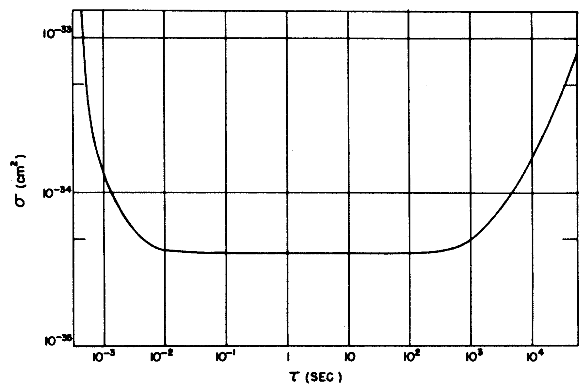

FIG. 3. Upper-limit cross section vs mean life.

Christy[4] has made a rough calculation of the theoretical cross section for $He^3(p, \gamma)Li^4$. That theoretical value, which is based on the reasonable assumptions of s-wave proton capture and a Li^4 ground-state assignment of 1^- or 2^-, depends on the assumed binding energy. If Li^4 were barely bound, σ should be in the neighborhood of 10^{-7} barn. A binding energy of 1 Mev would introduce some cancellation in the matrix element, and give the smaller value of 10^{-8} barn. Christy estimates that, if Li^4 were bound, one could expect $\sigma > 10^{-9}$ barn, which is greater by 25 times than the experimental limit, assuming a reasonable mean life for Li^4. Thus, one can assert that Li^4 is not bound.

This conclusion, which is based on a theoretical argument equally with the experimental finding, is extremely important in connection with the application to astrophysics. Were Li^4 actually bound, and were the upper limit of 4×10^{-11} barn the actual $He^3(p, \gamma)Li^4$ cross section, the cross section factor[5] would be 2.3×10^{-7} kev-barn. In such an instance, the stars would consume He^3 via the $He^3(p,\gamma)Li^4$ process rather than by the $He^3(He^3, He^4)2p$ reaction. Indeed, a cross section 10^{10} times smaller than the present experimental upper limit would enable the $He^3(p,\gamma)Li^4$ reaction to compete with the direct process $He^3(p, \beta^+\nu)He^4$, which[6] is of significance at very low temperatures ($T<2\times10^6$ °K). Thus, the observations reported in this paper cannot absolutely deny an astrophysical role to Li^4, but the implication of the data and theory is strong that Li^4 is not particle-stable and hence does not in fact have such a role.

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MEASUREMENT OF THE SPIN AND PARITY OF THE ANOMALOUS INELASTIC STATES IN Ni^{58} AND Ni^{60}†

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In the inelastic scattering of charged particles of intermediate energy as measured with low-resolution detectors, a number of experimenters have observed structure in the spectra at an excitation energy where one previously would have expected only a continuum.[1-3] The details of the structure observed by the different experimenters depend rather critically on the precise resolution used, but generally speaking these experiments have shown a strong peak corresponding to leaving the nucleus excited to about 2.5 Mev for elements with $Z \geqslant 30$. Further structure is seen particularly for elements with $Z < 30$ at an excitation energy of about 4.5 Mev. In this note we wish to report on the experiments establishing the spin and parity of the 4.5-Mev structure in Ni^{58} and Ni^{60} as 3^-

Figure 1 shows the angular distributions of alpha particles scattered from Ni^{58} and Ni^{60}, respectively, leaving the target nucleus in the ground state and first excited state. Also shown in these figures are the angular distributions of the alpha particles which leave the nucleus with the excitation indicated and constitute the anomalous peak at the respective energies. The spectra from which these angular distributions were deduced are similar to those published earlier by Sweetman and Wall.[3] The scintillation spectrometer used for experiments was a NaI crystal cut sufficiently thin (~0.02 inch) so that the largest proton or deuteron light pulse produced in the crystal was smaller than the alpha-particle pulses of interest.

In a subsequent experiment a 3×3 inch NaI γ-ray spectrometer was used to measure the γ-ray spectrum in coincidence with the anomalous alpha-particle groups. A fast-slow coincidence circuit was used that enabled us to simultaneously measure the elastic alpha-particle–γ-ray counting rate as well as the inelastic–γ-ray coincidence rate. This enabled us to show that the chance coincidence rate was in fact practically negligible and to make any minor correction (< 10%) for it. Details of this scheme will be published later. Figure 2 shows typical γ spectra in the case of Ni^{58} and Ni^{60}. By calibrating with a Na^{24} source we were able to determine the absolute efficiency of our γ-ray detector. Taking into account solid angle as well as intrinsic efficiency, the over-all efficiency was typically of the order of 7×10^{-3}. By summing all the counts in the energy interval