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Isospin Mixing of States in ^{6}Li†

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Isospin mixing in the mass $A=6$ system is examined by measuring the deuteron decay branch of the ^{6}Li (5.36-MeV; $T=1$) state. The mixing to be expected due to the Mott-Schwinger part of the Coulomb interaction is calculated. The measured spectra do not show any positive evidence for deuteron decay of the ^{6}Li (5.36-MeV; $T=1$) state. However, the experimental upper limit for possible isospin mixing is still appreciably larger than that expected from the Mott-Schwinger interaction.

I. INTRODUCTION

There has been a great deal of interest recently in the isospin nonconserving reactions ^{12}C$(d,\alpha)^{10}$B (1.74 MeV, 0^+; $T=1$) and ^{16}O$(d,\alpha)^{14}$N (2.31 MeV, 0^+; $T=1$). Above $E_d=12$ MeV some apparent forward peaking of the angular distributions has been interpreted as indicating a direct-reaction mechanism.[1] Others, however, have found pronounced resonances in the excitation functions of both reactions and state that there is no convincing evidence that direct reactions contribute a major portion of the large isospin-forbidden cross sections.[2] Noble[3] has put forward a reaction mechanism whereby the structure is explained in terms of a two-step process by way of the 2^+ doublet in ^{6}Li [i.e., a $(d,{}^6\text{Li})$ pickup followed by a $({}^6\text{Li},\alpha)$ stripping reaction]. In ^{6}Li the two 2^+ states are quite close in energy, as shown in the first figure. Noble has shown that ~5% isospin mixing between the two states ^{6}Li (4.57, 2^+; $T=0$) and ^{6}Li (5.36, 2^+; $T=1$) would be sufficient to reproduce the cross sections seen in the (d,α) reactions. One test of this hypothesis would obviously be to measure the isospin mixing, α^2, where one describes the state $\psi(5.36,\ 2^+)$ as a mixture of pure isospin states $|5.36\rangle$ and $|4.57\rangle$ in terms of the mixing parameter α as

$$\psi(5.36,\ 2^+)=(1-\alpha^2)^{1/2}|5.36\rangle+\alpha\,|4.57\rangle\,.$$

In L-S coupling, Barker[4] predicts three 2^+ states in ^{6}Li quite close in excitation. Of these, two have isospin $T=1$ and one $T=0$. If one restricts consideration to configurations having a proton and a neutron in the $1p$-shell outside an α core, then we can only get isospin mixing through the Mott-Schwinger part of the electromagnetic interaction. We do know something of the strength of this interaction and from this can calculate the resulting mixing, as shown in Sec. 5. As this is very small, any appreciable mixing can only come from the charge-dependent part of the nuclear force itself and the measurement of an appreciable isospin mixing would serve as a direct measure of such a force.

A way in which one can study the isospin purity of these $T=1$ levels is to compare cross sections in analog reactions. Thus one can compare the ^{7}Li$(d,{}^3\text{He})^6$He (0^+ and 2^+) differential cross sections to the ^{7}Li$(d,t)^6$Li (0^+ and 2^+) cross sections, respectively. Such measurements have been made by Baker, Cameron, and Chant.[5] Agreement with the prediction for the 0^+ state is very good. Similar measurements have been made by Debeve, Garvey, and Hingerty[6] and yield a weighted mean of 2.01 ± 0.03 for the ratio. Thus, as is to be expected, the 0^+ states indicate very pure isospin. A similar comparison for the 2^+, $T=1$ states is complicated by the large breakup background. The extracted ratios are about 1.6 and 1.8 ± 0.3, respectively, for the two experiments. From this ratio of 1.8 ± 0.3, Debevec, Garvey, and Hingerty[6] have calculated an isospin mixing $\alpha^2=0.008^{+0.06}_{-0.08}$. This calculation, however, does not take account of the $^{33}P_2$ component of the 5.36-MeV state. Barker[7] has recalculated the value of α^2 including the $^{33}P_2$ configuration and arrives at a result of $\alpha^2=0.02^{+0.16}_{-0.02}$. Thus the upper limit on α^2 is 0.18.

The alternative approach of measuring the deuteron decay of the ^{6}Li (5.36, 2^+; $T=1$) state formed in a sequential reaction has also been attempted. The first requirement of such a reaction is that the (2^+, $T=1$) state be formed preferentially, as the (2^+, $T=0$) state at 4.57 MeV is known to have a very large deuteron width, Γ_d, and would make it difficult to extract a small branch for the (2^+, $T=1$) state. Both the ^{7}Li$({}^3\text{He},\alpha)$ and ^{9}Be(p,α) reactions satisfy this criterion, whereas, for example, the ^{6}Li$({}^3\text{He},{}^3\text{He}')$ reaction is not suitable.[8]

A measurement of the ^{9}Be$(p,\alpha)^6$Li (5.36, 2^+; $T=1$) reaction has been made by Baker *et al.*[9] at a proton energy of 22 MeV. It is found that the breakup of the 5.36-MeV state into the allowed $\alpha+p+n$ channel is dominant and no structure can be attributed to deuteron decay of the 5.36-MeV state.

Three measurements have recently been reported of the ^{7}Li(^{3}He, α)^{6}Li (5.36, 2^+; $T=1$)$\rightarrow \alpha + d$ reaction. These, however, seem to be in some disagreement. Cocke and Adloff[10] suggest an upper limit on the deuteron decay branch of 2% but the later data of Kane, Lambert, and Treado[11] seem to indicate a larger contribution, while Artemov *et al.*[12] assign an upper limit of $\alpha^2 < 0.05$. Because of these differences, we have again studied this reaction.

II. EXPERIMENTAL DETAILS

In this experiment, we have made simultaneous measurements of the ^{7}Li(^{3}He, α)^{6}Li and ^{7}Li-(^{3}He, αd)α reactions. The ^{3}He particles of 1.45 MeV (lab) were obtained from the University of Alberta model CN Van de Graaff accelerator.

The target was prepared by evaporating isotopically enriched ^{7}Li *in situ* onto thin carbon foils. This technique was used to allow continuous monitoring of the ^{7}Li thickness deposited during evaporation by observing elastic scattering of 4-MeV protons.

Totally depleted surface-barrier silicon detectors were used for the detection of charged particles. The α-particle detector, 75 μm thick, was placed at an angle, θ_α, of 22.5° (lab) and, with collimators, subtended a solid angle of 7 msr. A nickel foil, 1.64 mg cm^{-2} thick, placed in front of the α detector, completely stopped the elastically scattered ^{3}He particles. It also served as an absorber for ^{6}Li recoils resulting in a clean α-particle spectrum. A spectrum obtained under these conditions is shown in Fig. 2. The states of ^{6}Li are indicated; as can be seen the 4.57-MeV state is not evident.

For the detection of α-d coincidences, a second detector, 300 μm thick, was placed at angles, θ_d, of -90 and $-120°$ (lab) for the two spectra obtained. These correspond to deuteron angles of 46 and 89° in the recoil ^{6}Li (5.36-MeV) system, respectively. The collimators for this detector subtended a solid angle of 10 msr. A 1.09-mg cm^{-2} nickel foil placed in front of the detector facilitated the separation of the ^{7}Li(^{3}He, αd) and ^{7}Li(^{3}He, $\alpha\alpha$) kinematic loci in the two-parameter spectra. All data acquisition was accomplished using standard methods, and the single- and dual-parameter spectra were stored in a Honeywell 516 computer.

The choice of energy and angles was made as follows:

(i) The incident energy of 1.45 MeV enhances the production of the 5.36-MeV state. This was pointed out previously[10] and a crude check in the present case verified the fact.

(ii) The α-particle angular distribution of the 5.36-MeV state shows an enhancement at about 20–25° (lab). This was determined by a measurement of the angular distribution in the forward direction.

(iii) Having fixed $E(^3\text{He})$ and θ_α, the two values of θ_d were chosen to provide the most favorable situation for the detection of α-d coincidences corresponding to the deuteron decay of the ^{6}Li (5.36-MeV) state. At $\theta_d = -120°$, contributions from the deuteron decay of the ^{6}Li (2.18-MeV) state also appear on the kinematic locus of the (^{3}He, αd) reaction. This can be seen by examination of Fig. 3. It was possible to make a check of the experimental technique by measuring the branching ratio of the deuteron decay of this state and

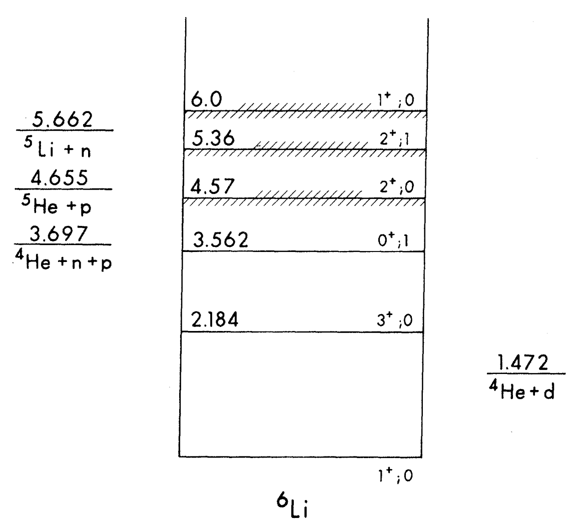

FIG. 1. ^{6}Li level scheme for region of interest.

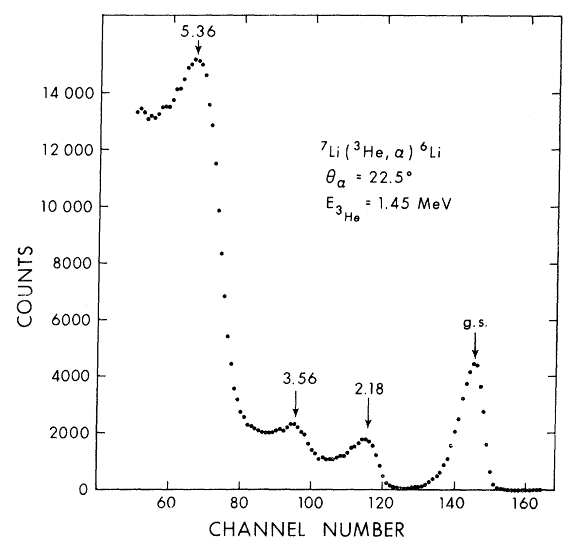

FIG. 2. α-particle singles spectrum from 75-μm-thick totally depleted surface-barrier silicon detector at 22.5°.

assuming a isotropic decay in the recoil ^{6}Li system. A result in good agreement with the known 100% decay branch was found. The second value chosen, $\theta_d = -90°$, was dictated by the desire to remove the large enhancement due to the formation and decay of the ^{8}Be (2.9-MeV) state from the reaction ^{7}Li(^{3}He, $d\alpha$)α. As can be seen from the kinematics for the two angular pairs, shown in Fig. 3, the contribution is much further removed from the region of interest when $\theta_d = -90°$ than when $\theta_d = -120°$.

III. RESULTS

To determine the yield of the 5.36-MeV level, an attempt was made to fit the singles spectra with contributions from three-body and four-body phase space together with a Breit-Wigner resonance shape for the 5.36-MeV level. It was found, however, that a satisfactory fit could not be obtained, it being necessary to add an additional broad peak at about 6 MeV excitation. The existence of the broad $^{13}D_1$ state in ^{6}Li, at about this excitation, has already been indicated from phase-shift analysis of d-α elastic scattering.[13] The parameters reported by different authors for the state differ widely; however, all agree that it is probably greater than 1.0 MeV wide.

Relatively small differences in the parameters used for this state had a marked effect on the yield extracted for the 5.36-MeV level. As an example of this problem, Table I presents a list of the $\alpha + d$ yield of the 5.36-MeV state as a function of the excitation energy of the $^{13}D_1$ state. Because of these effects, it was decided that a fit to the region of interest using the known parameters[14] for the 5.36-MeV state ($\Gamma = 560$ keV) and adding a second-order polynomial to represent the remainder would yield the most reliable result.

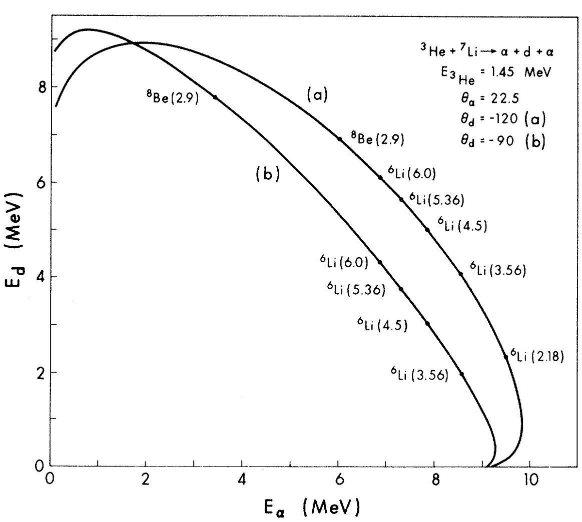

FIG. 3. Kinematic loci for the ^{7}Li(^{3}He, αd)α reaction with the α-particle detector at 22.5° and the deuteron detector at (a) −120° and (b) −90°. Note the position of the ^{8}Be 2.9-MeV state in the latter case.

The results of the coincidence measurements projected onto the α-particle energy axis are shown in Figs. 4 and 5. General features of note are the dominance of the contribution from the ^{8}Be (2.9-MeV) state at $\theta_\alpha = 22.5°$, $\theta_d = -120°$ and its much smaller effect at the other angle setting. In the data at $\theta_d = -120°$, an enhancement due to the deuteron decay of the ^{6}Li (4.57, $T = 0$) state is also clearly evident, even though no contribution from this level to the singles spectrum was discernable. The large yield from the decay of the ^{6}Li (2.18-MeV) state seen at $\theta_d = -120°$ disappears at $\theta_d = -90°$ as it is no longer kinematically allowed. A shoulder in both spectra which may be a broad state about 5.8 MeV excitation is also discernable. The major decay mode of the ^{6}Li (5.36 MeV, $T = 1$) level must be a breakup into $\alpha + p + n$. We include in Fig. 5 a projection of the four-body continua resulting from this decay mode and as expected a large peak is evident. The width extracted for the ^{6}Li (5.36-MeV) level from these data (560 keV) was in agreement with the previously reported value, and was used in the extraction of the deuteron decay branch.

As shown in the kinematic plots in Fig. 3, there are only a small number of states contributing sequential decays in the region of interest. We have attempted to fit the spectra using the known parameters for the levels indicated in ^{6}Li and ^{8}Be. As discussed in the case of the singles spectra, it was found necessary to include a broad ^{6}Li (6.0-MeV) state; the parameters used for this state affecting the $\alpha + d$ yield of the 5.36-MeV state as shown in Table I. The composite fits to the coincidence spectra obtained in this manner are included in Figs. 4 and 5.

To extract the branching ratio (B.R.) for deuteron decay of the ^{6}Li (5.36, $T = 1$) level it was decided that the most reliable procedure was to fit the data in the region corresponding to about 4.5 to 6.0 MeV excitation in ^{6}Li. Again, because

TABLE I. Yield of 5.36-MeV state as a function of the position of the $^{13}D_1$ state in ^{6}Li for $\theta_\alpha = 22.5°$ and $\theta_d = 90°$. Width of the $^{13}D_1$ state fixed at 1.8 MeV.

$^{13}D_1$ excitation energy (MeV)	Yield of 5.36 ($\alpha + d$) (Counts)	B. R.
6.06	473	0.019
5.94	348	0.014
5.82	211	0.009
5.70	62	0.003

of the uncertainties surrounding the $^{13}D_1$ level we have used a polynomial plus a Breit-Wigner curve centered at 5.36 MeV excitation. The fit to the data was made using a least-squares routine, the goodness of fit being determined from the χ^2 per degree of freedom. An initial fit was made using just the three parameters of the polynomial and the χ^2 noted. The peak at 5.36 MeV excitation was then added and, although a small amplitude was required to obtain the best fit, the χ^2 per degree of freedom did not improve over that obtained with no Breit-Wigner resonance. From the above fits we have estimated an upper limit for deuteron decay of the 5.36-MeV state by taking the three-parameter polynomial fit and adding all counts above the computed curve between 5.00 and 5.70 MeV excitation. We calculate the limit on the branching ratio separately from each coincidence spectrum by assuming an isotropic decay of the ^{6}Li in its center-of-mass system. The solid angle of the deuteron detector was also transformed to the ^{6}Li recoil system. The resulting upper limits on the deuteron branch were 1.2% for the 90° data and 0.85% for the 120° data. The corresponding fits are shown in Fig. 6.

Averaging the results for the two sets of angles we get an upper limit for the deuteron branch of 1.0%.

IV. EXTRACTION OF THE ISOSPIN MIXING PARAMETER

In previous investigations of this reaction[10, 12] two different techniques have been used to extract the isospin mixing parameter α. Cocke and Adloff calculated an "allowed" deuteron width, $\Gamma_{d,\,\mathrm{all}}$, as $2P\times$(single-particle reduced width),[2] where P is the α-d penetrability. This results in an "allowed width" of 2.52 MeV, calculated for a channel radius of 3.7 fm. Taking our experimental partial width, $\Gamma_d = \mathrm{B.R.}\times\Gamma \leq 0.01\times 560$ keV $= 5.6$ keV, we thus obtain a reduced width from the relationship $\alpha^2 = \Gamma_d/\Gamma_{d,\,\mathrm{all}} \leq 2\times10^{-3}$. Barker[7] has however, pointed out that this $\Gamma_{d,\,\mathrm{all}}$ is a formal (in the R-matrix sense) width, and may be seriously in error. It thus seems preferable to use the approach of Artemov *et al.*[12] where the mixing is written as

$$\alpha^2 = \frac{\Gamma_d}{\Gamma_{4.57}}\,\frac{P_{4.57}}{P_{5.36}}\,.$$

Calculated for an interaction radius of 3.7 fm,

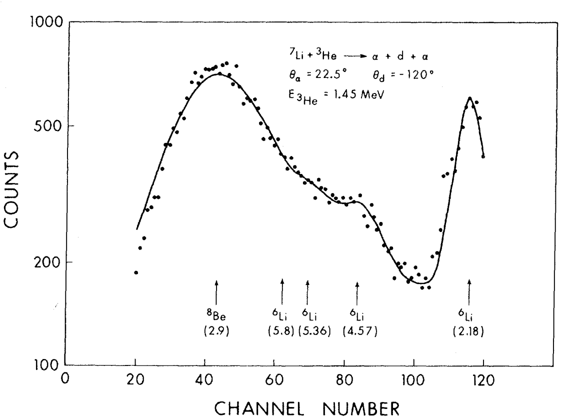

FIG. 4. Projection of the kinematic locus data for case (a) of Fig. 3 onto the α-particle energy axis. The positions of the ^{6}Li and ^{8}Be states are shown.

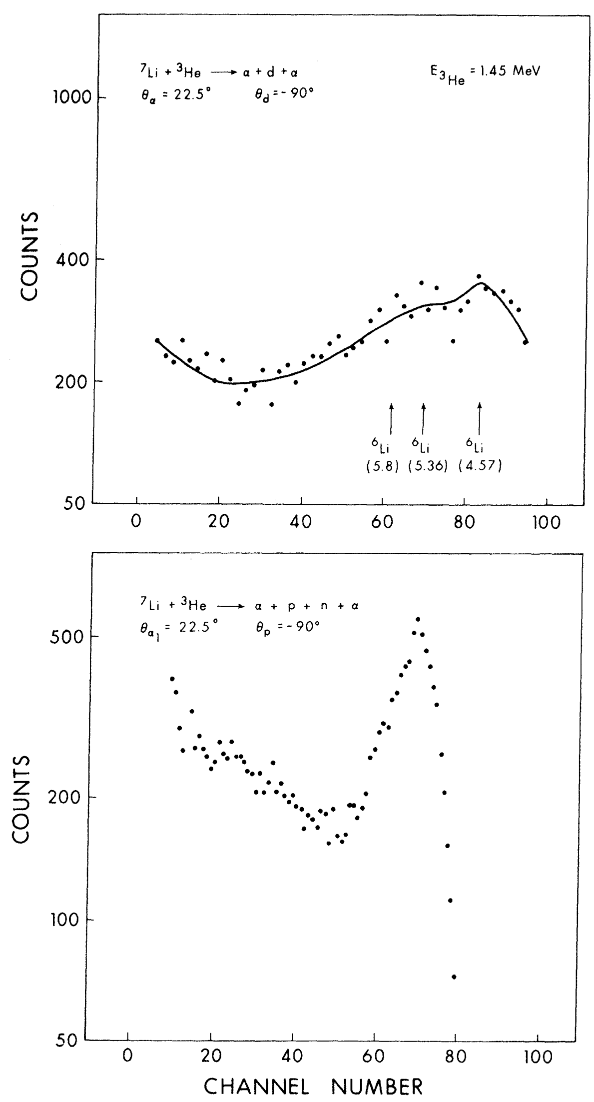

FIG. 5. Upper: Projection of the data (locus region only) for case (b) of Fig. 3 onto the α-particle energy axis. The positions of the ^{6}Li states are shown. Lower: Projection of the four-particle breakup region of these data onto the same axis. The large peak is due to the ^{6}Li(5.36) state.

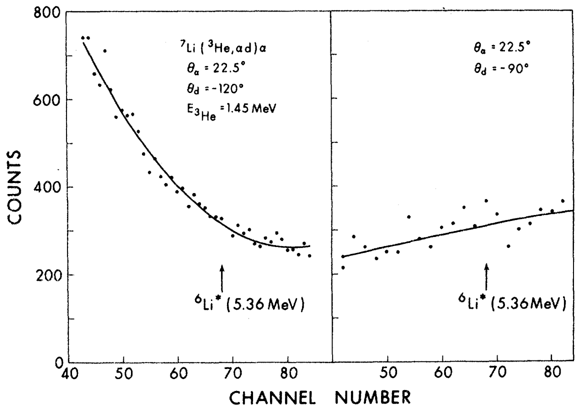

FIG. 6. Regions of projected loci [corresponding Fig. 4 and 5(a)] near 5.36 MeV excitation showing polynomial fits.

the ratio of penetrabilities for deuteron decay from the 5.36- and 4.57-MeV states is 0.7. Thus if one takes $\Gamma_{4.57} = 500$ keV, we have $\alpha^2 \leq 8\times10^{-3}$. The value $\Gamma_{4.57} = 500$ keV, has been used here since it is in reasonable agreement with the spectra obtained from our experiment and results of previous experiments.[15,16] It should be noted, however, that if the greater width indicated by α-d scattering[13] were used in the analysis, the value of α^2 would be reduced.

V. ISOSPIN MIXING DUE TO THE MOTT-SCHWINGER INTERACTION

Before interpreting any measured isospin impurity as suggesting some fundamental charge-dependent part of the nuclear force, one must calculate and subtract out the mixing due to known electromagnetic effects. To first order in perturbation theory

$$\alpha = \frac{\langle 4.57|H'|5.36\rangle}{E_{5.36} - E_{4.57}},$$

where H' is the interaction responsible for the mixing. For the case of interest here we have

$$|5.36\rangle \rightarrow |5.36,\ 2^+,\ T=1\rangle = a\,{}^{31}D_2 + b\,{}^{33}P_2\,,$$

$$|4.57\rangle \rightarrow |4.57,\ 2^+,\ T=0\rangle = {}^{13}D_2$$

using the notation ${}^{2T+1\,2S+1}L_j$, where the coefficients $a = 0.833$ and $b = 0.553$ have been obtained by Barker.[4] Clearly the ordinary Coulomb interaction which is diagonal in L and S cannot mix these two states. The Mott-Schwinger[17] interaction, which mixes spin, orbital angular momentum, and isospin, can however, contribute to H'. A rough estimate of its contribution has been made in Ref. 6. We want to make a more detailed calculation here.

If we consider ^{6}Li as made up of an α-particle core plus two valence nucleons, then we obtain two contributions to the Mott-Schwinger part of H'. The first, $H_{\rm core}$, describes the interaction of the p-shell nucleons with the core and can be written as

$$H_{\rm core} = \frac{e^2\hbar^2}{2m^2c^2}\sum_i \frac{1}{r_i}\frac{dV_c}{dr_i}\,\vec{1}_i\cdot\vec{\sigma}_i[(\mu_p - \tfrac{1}{2})P_p + \mu_n P_n]_i\,,$$

where the sum is over all nucleons in the outer shell. Here $\vec{1}_i$, $\vec{\sigma}_i$, and r_i are the orbital angular momentum, Pauli spin operator, and coordinate of the ith nucleon and P_p and P_n are isospin projection operators picking out protons and neutrons, respectively. V_C is the Coulomb potential due to the core, with the charge e factored out. We use $\mu_p = 2.79$, $\mu_n = -1.91$, $e^2/\hbar c = 1/137$, and m is the nucleon mass.

The second contribution, H_{np}, which to our knowledge has not been previously calculated, is that due to the interaction of the outer nucleons among themselves. It can be written as

$$H_{np} = \frac{e^2\hbar^2}{2m^2c^2}\sum_{i\neq j}\frac{1}{r_{ij}}\frac{dV_j}{dr_{ij}}\,\vec{1}_{ij}\cdot\vec{\sigma}_i[(\mu_p - \tfrac{1}{2})P_p + \mu_n P_n]_i[P_p]_j\,,$$

where $r_{ij} = |\vec{r}_i - \vec{r}_j|$, $\vec{1}_{ij}$ is the angular momentum of i relative to j and V_j is the Coulomb potential due to particle j, the proton in our case.

Given these interactions, one can calculate the required matrix elements by straightforward techniques. For $\langle H_{\rm core}\rangle$ it is easiest to first transform the L-S coupled states to jj coupled ones, since the operator $\vec{1}\cdot\vec{\sigma}$ is diagonal in the jj representation. Since H_{np} depends on operators in the relative coordinates only, to evaluate $\langle H_{np}\rangle$ we first assume harmonic-oscillator wave functions and then use the fact that they can be easily separated into wave functions depending, respectively, on the relative and center-of-mass coordinates[18] using tabulated coefficients.[19]

The results thus obtained, using the wave functions $|5.36\rangle$ and $|4.57\rangle$ given above, are

$$\langle 4.57|H_{\rm core}|5.36\rangle = -\left(\frac{3}{2}\right)^{1/2}\frac{Z}{2}(\mu_n - \mu_p + \tfrac{1}{2})\frac{e^2\hbar^2}{m^2c^2}\left(a - \frac{b}{\sqrt{2}}\right)\times\langle R_{11}(r)|\,\frac{1}{r}\frac{dV_c}{dr}\,|R_{11}(r)\rangle\,,$$

$$\langle 4.57|H_{np}|5.36\rangle = -\left(\frac{3}{2}\right)^{1/2}\mu_n\frac{e^2\hbar^2}{m^2c^2}\,a\left\langle R_{12}\left(\frac{r}{\sqrt{2}}\right)\right|\frac{1}{r}\frac{dV_p}{dr}\left|R_{12}\left(\frac{r}{\sqrt{2}}\right)\right\rangle\,,$$

where $Z=2$ in this case and where R_{11} and R_{12} are the lowest harmonic-oscillator radial wave functions with $l=1$ and 2, respectively. To obtain α one simply divides by the energy difference 5.36 $-4.57=0.79$ MeV. Observe that the contribution from the $^{33}P_2$ component of the $|53.6\rangle$ state (that proportional to b) is significant, being about half of the contribution from the main $^{31}D_2$ component and tending to cancel it. Also the H_{np} contribution to α has the same sign as that from H_{core}.

For the purpose of numerical estimates, we calculated the Coulomb potentials assuming uniform charge densities for the α-particle core and for the proton with equivalent radii 2.21 and 1.05 fm, respectively.[20,21] We took 1.745 fm as the best value for the harmonic-oscillator parameter r_0.[22] The resulting contributions to $|\alpha|$ were 0.0110 from H_{core} and 0.0032 from H_{np}, which gives $|\alpha| = 1.4\times10^{-2}$ and $\alpha^2=2.0\times10^{-4}$. The mixing is somewhat sensitive to r_0 and ranges from $\alpha^2=3.4\times10^{-4}$ for $r_0=1.5$ fm, to $\alpha^2=1.2\times10^{-4}$ for $r_0=2.0$ fm. These values for α^2 are about the same as the estimate given by Debevec, Garvey, and Hingerty[6] but the agreement is coincidental since their neglect of the reasonably important $^{33}P_2$ contribution and the H_{np} contribution is offset by the use of a much larger equivalent radius, 2.54 fm, for the α-particle core. In summary, we note that the mixing we calculate resulting from the Mott-Schwinger interaction is still significantly smaller than the upper limit obtained in the present experiment.

Recently DeVries *et al.*[23] also looked at the isospin mixing in ^{6}Li, but investigated impurities in the 4.57-MeV state instead of the 5.36-MeV state. The resulting mixing parameter is somewhat different from α for reasons which we now wish to discuss. If one wishes to consider the $T=1$ mixing into the $T=0$, 4.57-MeV state, one must include contributions from both the 5.36-MeV state and from a third state predicted by Barker at 7.8 MeV, namely,

$$|7.8\rangle \to |7.8,\ 2^+,\ T=1\rangle = -b\,{}^{31}D_2 + a\,{}^{33}P_2\,.$$

Thus the state being investigated is

$$\begin{aligned}\psi(4.57,\ 2^+) &= (1-\alpha^2-\beta^2)^{1/2}|4.57\rangle - \alpha|5.36\rangle + \beta|7.8\rangle\\ &= (1-\alpha^2-\beta^2)^{1/2}\,{}^{13}D_2 - (a\alpha+b\beta)\,{}^{31}D_2\\ &\quad -(b\alpha-a\beta)\,{}^{33}P_2\,.\end{aligned}$$

The parameter α is the same as before, with the minus sign coming from the change in sign of the energy denominator. The parameter β can be calculated from the matrix element above with appropriate numerical values for a and b. For $r_0 = 1.745$ fm we find $\beta=-7\times10^{-3}$ which is about half of α since the larger energy denominator is partially offset by the fact that now the D- and P-state contributions add, instead of cancel. Decays of this state into a d^* in the $^1S_0$ state can proceed only from the $^{31}D_2$ component since the $^{33}P_2$ state has spin one. (One must also project out of the $^{31}D_2$ state the component with relative angular momentum zero. However, in the ratio to elastic d-α scattering, the factor so obtained cancels the similar factor obtained by projecting the $^3S_1$ out of the 4.57-MeV $^{13}D_2$ component.) Thus the effective mixing parameter of interest for the experiment of Ref. 23 is $\alpha_{\text{eff}}=(\alpha a+b\beta)=2.5\times10^{-4}$, which is only coincidentally about the same as α^2. This value is slightly larger than their experimental upper limit of 10^{-4}. One can, however, easily understand a factor of 3 or so uncertainty in α_{eff}^2 in terms of the uncertainties in, for example, the parameters a and b and in the specific choices of radial wave functions and charge distribution. Thus the difference may not be significant. (If, however, this limit is really given by the cross section for the $^3S_1$ $T=0$ state and if in fact no $^1S_0$ can be seen, then the measured α_{eff}^2 must be significantly smaller than 10^{-4}, and smaller than the effects of the known Mott-Schwinger contribution.)

VI. DISCUSSION

The measured spectra do not show any positive evidence for decay of the ^{6}Li (5.36-MeV, $T=1$) state into an α particle and a deuteron. Thus we confirm the results reported by Cocke and Adloff.[10] From the polynomial fits described, we have obtained the present upper limit on the $\alpha+d$ decay branch of the 5.36-MeV state resulting in an upper limit on the isospin mixing of $\alpha^2 \leq 8\times10^{-3}$. The spectral analysis of Kane, Lambert, and Treado[11] may be in error because they did not consider the possible existence of a state in ^{6}Li around 6 MeV excitation. Although we did not see such a state directly we found, as is described in the text, that its inclusion was necessary to obtain fits to our singles and coincidence spectra when using a function composed of Breit-Wigner resonances. Kinematically this extra resonance seems to be consistent with being a state in ^{6}Li.

A theoretical estimate of the mixing caused by the Mott-Schwinger interaction between the outer nucleons and the α-particle core and by a similar interaction between the two nucleons has been calculated. The value obtained for α^2 is $\sim 2\times10^{-4}$ but could vary by as much as a factor of 3 or 4 due to uncertainties in the parameters used. Nevertheless, the calculated mixing is still about an order of magnitude smaller than the upper limit obtained in the present experiment. The experiment of DeVries *et al.*,[23] in which the decay of the 4.57-MeV level into an $\alpha + d^*$ was examined, results, in contrast, in a situation where the upper limit is slightly lower than the predicted mixing. This is hard to understand, unless there are other contributions to α of the same order but opposite sign.

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