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6.11 Spin Dependence of the Isospin Forbidden Decay $^8Be(E_x = 27.5\ MeV) \rightarrow d + {}^6Li$

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The isospin forbidden decay of the lowest T = 2 state in ^8Be (E_x = 27.5 MeV, $J^\pi = 0^+$) has been studied by means of the reaction d + $^6Li \rightarrow \alpha + \alpha$. Although both the initial and final states of this reaction have T = 0, the T = 2 state can be seen[1,2] as a narrow ($\Gamma \approx 5$ keV) resonance in the d + $^6Li \rightarrow \alpha + \alpha$ cross section. In the present experiment we have used a polarized deuteron beam to measure angular distributions of the cross section and analyzing powers for the reaction $^6Li(\vec{d},\alpha)^4He$ on and off resonance. In addition, a polarized ^6Li beam has been used to measure the off-resonance analyzing powers for the reaction $^2H(^6\vec{Li},\alpha)^4He$.

The measurements were carried out at the University of Wisconsin tandem accelerator laboratory. Measurements of the cross section and deuteron analyzing powers were obtained at the resonance energy (E_d = 6.96 MeV), above the resonance (E_d = 7.04 MeV) and below the resonance (E_d = 6.88 MeV), using procedures similar to those described in Ref. [3]. The ^6Li analyzing powers were measured above (E_{Li} = 21.03 MeV) and below (E_{Li} = 20.55 MeV) the resonance. The ^6Li beam polarization was assumed to be constant over the course of the experiment and was determined by making use of the fact that for a given CM angle and energy, A_{yy} must be the same for $^6Li(\vec{d},\alpha)^4He$ and $^2H(^6\vec{Li},\alpha)^4He$.

The measurements are shown in Fig. 1. Since the final state involves identical particles, the observables must be either symmetric or antisymmetric about $\Theta_{CM} = 90°$. The data have been plotted accordingly. The "off resonance" results are averages of the measurements taken above and below the resonance.

The data shown in Fig. 1 contain information about the spin dependence of the isospin forbidden decay $^8Be(T = 2) \rightarrow d + {}^6Li$. To extract this information we have carried out an analysis in which the matrix elements of the reaction are determined directly by fitting the data. In general, the collision matrix elements[4] for a nuclear reaction are written as $U^j_{\ell s \ell' s'}$, where ℓ and s (ℓ' and s') are respectively the orbital angular momentum and channel spin in the entrance (exit) channel, and where j is the total angular momentum. For d + $^6Li \rightarrow \alpha + \alpha$, the final state has s' = 0, so j = ℓ'. Identical particle symmetry requires ℓ' to be even, and by parity conservation ℓ must also be even. These restrictions greatly reduce the number of nonzero matrix elements. Since the T = 2 state has $J^\pi = 0^+$, only the j = 0 matrix elements can resonate. Two such matrix elements occur: one with ℓ' = s = 0 and a second (which we call the spin-flip amplitude) with ℓ = s = 2.

In fitting the measurements, the on- and off-resonance data sets were analyzed simultaneously. On resonance the two j = 0 matrix elements are written as the sum of a background term, $U^{bkg}_{\ell,s,j}$, and a resonant term, $U^{res}_{\ell,s,j}$, while for the off-resonance data only the background term is retained. The matrix elements with j ≠ 0 are constrained to be identical on and off resonance. All matrix elements with $\ell \leq 6$ were included in the analysis. The best fit is shown by the curves in Fig. 1. This fit has $\chi^2/N = 1.15$, which corresponds to a confidence level of 0.16.

Having determined the collision matrix elements it is now possible to extract separate partial widths (Γ_0 and Γ_2) for the decay of the ^8Be T = 2 state into the d + ^6Li states with s = 0 and 2. Assuming that the resonant matrix elements can be written in terms of simple Breit-Wigner expressions [see Ref. [4]] one obtains

$$\Gamma_2/\Gamma_0 = |U^{res}_{2,2,0}|^2 \ / \ |U^{res}_{0,0,0}|^2. \qquad (1)$$

From the parameters of the best fit the ratio of partial widths is found to be

$$\Gamma_2/\Gamma_0 = 0.31 \pm 0.10. \qquad (2)$$

The central point of interest in this result is that the partial width for decay into the spin-flip channel differs from zero by a significant amount. If we attempt to

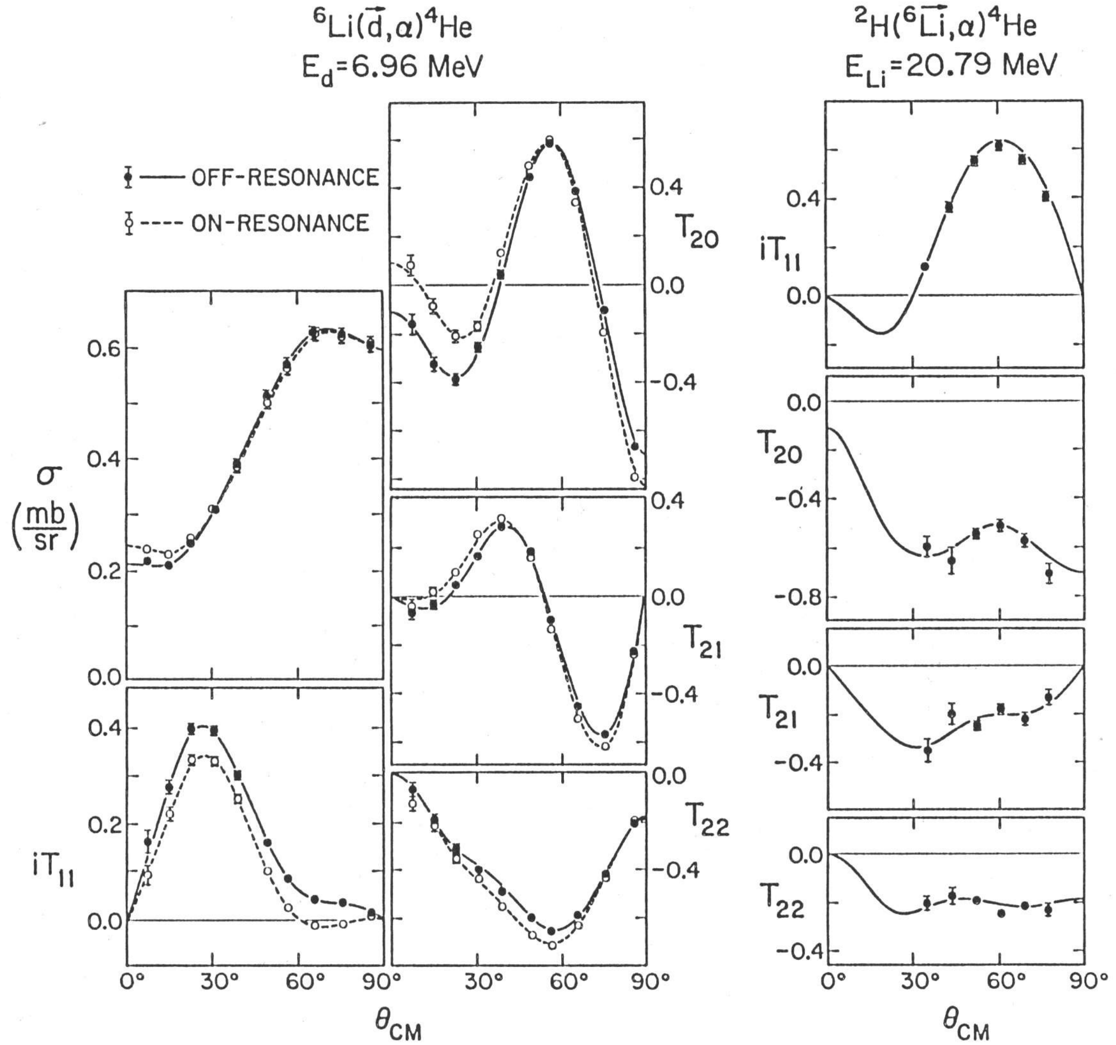

Fig. 1. Measurements of the cross section and analyzing powers for the reaction d + ^{6}Li → α + α in the neighborhood of the resonance corresponding to the lowest T = 2 state in ^{8}Be. The curves are fits to the data.

reproduce the measurements in Fig. 1 with $U^{res}_{2,2,0}$ set to zero, the best fit χ^2/N increases to 1.78 (corresponding to a confidence level of about 1×10^{-5}).

A priori one would expect Γ_2 to be small, since the isospin forbidden decay presumably results primarily from electromagnetic interactions which are spin independent. However it should be emphasized that the observation of a nonzero Γ_2 can not, by itself, be taken as evidence for the existence of isospin violating forces which depend on spin (isospin conserving tensor forces can give rise to wave function admixtures which make it possible for Coulomb forces to connect the T = 2 state to the d + ^{6}Li spin-flip channel). Nevertheless, the present measurement does provide us with a potentially valuable piece of information about the spin dependence of the isospin forbidden decay.

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