Title
DETERMINATION OF LEAD IN ATMOSPHERIC AIR AND IN ALUMINUM BY 3He-INDUCED NUCLEAR REACTIONS

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We report preliminary results of a high resolution study of the photon spectra in the 50-150 MeV region associated with stopped π^- absorption on ^{3}He and ^{6}Li.

I. EXPERIMENT

The measurements were performed at the Berkeley 184-in. Cyclotron with an experimental arrangement similar to that described in Ref. 1. The principal modifications have been to replace the optical spark chambers of the pair spectrometer with a set of three wire spark chambers and to increase the solid angle by a factor of 2. The targets consisted of 200g of ^{6}Li and 60g of liquid ^{3}He. A liquid Hydrogen target was employed in the calibration and a spectrum obtained with the new spectrometer is displayed in Fig. 1a. It can been seen that a resolution of 2 MeV (fwhm) at 130 MeV was achieved. The Panofsky ratio deduced from this spectrum is 1.59 ± 0.22.

II. RESULTS FOR ^{6}Li

The spectrum for ^{6}Li, displayed in Fig. 1c, exhibits three components: (1) a discrete γ-ray line at 134.0 MeV corresponding to the ^{6}He(g.s.) transition, (2) a continuum component associated with the ^{5}He + n + γ channel and which peaks at $\sim$ 115 MeV, (3) a broad resonance peak centered at an energy of $\sim$ 24 MeV relative to ^{6}He(g.s.).

The branching ratio for the direct transition to ^{6}He(g.s.) was determined by fitting the instrumental line shape, obtained from the

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Hydrogen spectrum, to the high energy region of the observed peak. The contribution from the unresolved 2^+ state at 1.8 MeV should thus be minimal. We obtain R_γ (g.s.) = radiative transitions/π-atom formed = 0.39 ± 0.10%. This differs considerably from the previous measurement 1.0 ± 0.1% by Deutsch et al.[2] Theoretical calculations based on an elementary particle treatment of nuclei have been performed by Delorme[3] who obtains R_γ = 0.75%, and by Werntz[4] who obtains 0.41%. Vergados and Baer[5] have performed a shell model analysis of this transition and obtained values in the range 0.40 - 0.42% depending on the choice of coefficients in the effective interaction. The form of the Hamiltonian used was that of Delorme and Ericson[6].

The continuum component of the spectrum, associated with the ^{5}He + n + γ reaction, is seen to be reasonably well described by the simple pole model of Dakhno and Prokoshkin[7]. For the calculation shown in Fig. 1c the proton separation energy parameter Δ was taken to be 9 MeV.

We tentatively identify the broad peak in our spectrum at $E_x \sim 24$ MeV as the T_z = + 1 analogue of the resonance in ^{6}Be observed at approximately the same energy. Measurements of the ^{3}He-^{3}He elastic scattering[8,9] and the radiative capture reaction[10] ^{3}He (^{3}He,γ)^{6}Be determined L = 3, S = 1, T = 1 for this resonance, and it has been identified with the ^{33}F state predicted at $\sim$ 27 MeV by Thompson and Tang[11]. Observation of the T_z = 0 member of this isobaric triad in ^{6}Li was reported by Ventura et al.[12]. To our knowledge, evidence for the T_z = + 1 member in ^{6}He is first reported here.

III. RESULTS FOR ^{3}He

The spectrum for ^{3}He, displayed in Fig. 1b, clearly shows the presence of all four γ-ray channels predicted in the theoretical study of A.M.L. Messiah[13]: (1) the t + γ line at 135.8 MeV (2) d + γ continuum with the end point energy of 129.8 MeV (3) the pnnγ continuum with an end point energy of 127.7 MeV (4) the t + π^o channel resulting in a uniform distribution of γ-rays between 53 and 86 MeV. Although the absolute branching ratios of each of these components is of considerable interest, we limit ourselves here to presenting our value of the Panofsky ratio, pending a more complete analysis of the relative photon detection efficiencies.

With our method of measurement, the Panofsky ratio for ^{3}He can be determined quite accurately relative to Hydrogen since the γ-ray energies are nearly identical for the two reactions. Thus the detection efficiencies need not be known precisely. Assuming a value of 1.53 for the Panofsky ratio for Hydrogen we obtain for ^{3}He

$$P(^3\mathrm{He}) = \frac{\omega(\pi^- + {}^3\mathrm{He} \to \pi^0 + t)}{\omega(\pi^- + {}^3\mathrm{He} \to \gamma + t)} = 3.48 \pm 0.40$$

This is considerably larger than 2.28 ± 0.18 measured by Zaimidoroga al.[14] It is also larger than the theoretical estimates of 2.0 by Messiah, and 2.70 by Ericson and Figureau[15]. The theoretical implications of the larger Panofsky ratios should be of interest.

Perhaps the most interesting feature of our data is the existence of a peak at ∿ 13 MeV relative to ^{3}He(g.s.). There has been much discussion in the literature regarding low-lying T = 1/2 and 3/2 states in the mass-3 system. Very recently, Chang *et al.*[16] have suggested that a T = 1/2 state exists in the 13-15 MeV excitation region of the ppn system. Although it is too early to reach any conclusions, the peak in our spectrum may be evidence for such a low-lying resonance in the mass-3 system.

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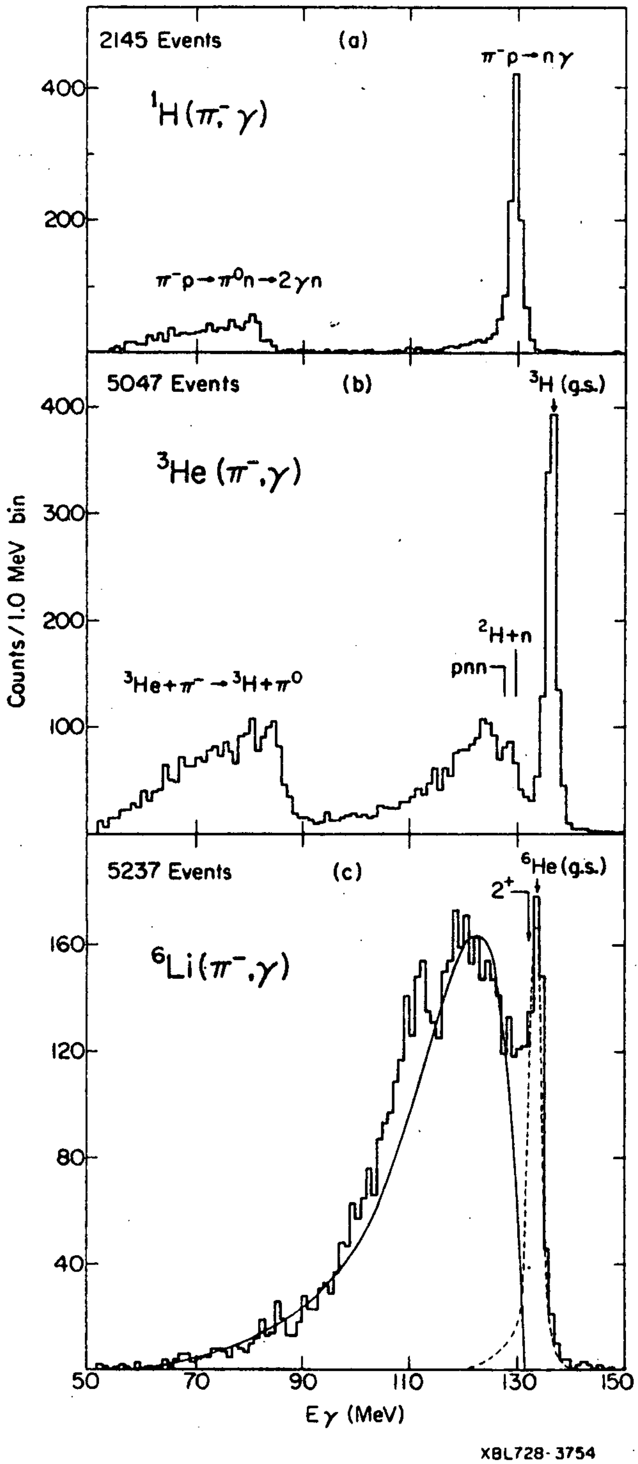

Fig. 1 Photon spectra from π^- absorption on ^1H, ^3He, and ^6Li. The solid curve in (c) represents a calculation using the pole model of Ref. 7 with arbitrary normalization.