Search for Electric Monopole Pairs from the 7.6-Mev State of C^{12}†

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A search was made for weak 7.6-Mev electric monopole pairs from the reaction $Be^9(\alpha,n)C^{12*}$ using a thin target, 5.7-Mev alpha particles, and a scintillation pair spectrometer. No 7.6-Mev pairs were seen with an intensity as great as 1.6×10^{-5} that of 4.43-Mev gamma rays. This result gives a limit of $\Gamma_{\pm e}/\Gamma_{\text{total}}<1.3\times10^{-4}$ for the ratio of the partial width for pair emission to the total width of the 7.6-Mev state. If an estimated alpha-particle width of 0.5 ev is taken for the total width of the 7.6-Mev state, then an upper limit of $\Gamma_{\pm e}<7\times10^{-5}$ ev is obtained for the partial width for pair emission of the 7.6-Mev state.

I. INTRODUCTION

IN order to calculate the reaction rate of the conversion of helium into carbon in red giant stars, it is necessary to know the partial width of the 7.65-Mev state of C^{12} for decay to the ground state.[1,2] Previous attempts to detect 7.6-Mev pairs from C^{12} have been unsuccessful.[3,4] The purpose of the present experiment was to search for electric monopole pairs from the 7.65-Mev state of C^{12} which were too weak to have been detected in an earlier experiment.[3] A preliminary report of this work was given at the New York Meeting of the American Physical Society, 1957.[5]

II. EXPERIMENTAL METHOD

A gamma-ray three-crystal pair spectrometer[6] was modified to detect monopole pairs with high efficiency by replacing the center NaI crystal with a plastic "well" scintillator. This modified spectrometer has an efficiency of 1.6% for the detection of electric monopole pairs, and a resolution of 17% for 5-Mev pairs. The efficiency for detection of gamma rays is low because of the small pair cross section in plastic. A description of this spectrometer has been published.[7]

III. RESULTS

Figure 1 shows the uncorrected pair spectrum obtained from the bombardment of a 0.1-mil beryllium foil with 5.7-Mev alpha particles from the Columbia Van de Graaff accelerator. A peak is observed corresponding to external pairs formed by 4.43-Mev gamma rays in the plastic scintillator. No pair line is observed at 7.65 Mev with an intensity as great as 0.4% that of the 4.43-Mev line.

The fraction of 4.43-Mev gamma rays which create external pairs in the plastic scintillator was calculated to be 1/250. This gives

$$\frac{\text{number of 7.6-Mev pairs}}{\text{number of 4.43-Mev gamma-rays}}<1.6\times10^{-5}.$$

This limit is a factor of 4 lower than that obtained by Bent, Bonner, McCrary, and Ranken[3] using a thick target and 4.3-Mev alpha particles, and a factor of 7 higher than that recently obtained by Goldring, Wolfson, and Wiener[4] using a thin target and 5.3-Mev alpha particles.

The relative populations of the 7.6- and 4.43-Mev states of C^{12} are known from the neutron measurements of Guier, Bertini, and Roberts[8] to be 1:8 under nearly the same experimental conditions as those of the present experiment. The limit obtained above for the

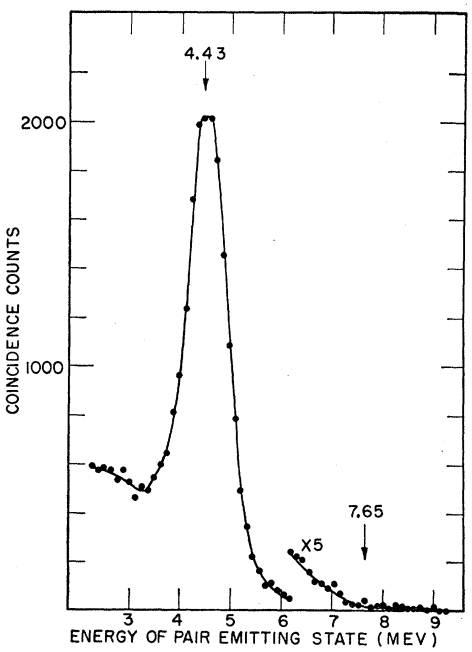

FIG. 1. Uncorrected pair spectrum obtained from the bombardment of a 0.1-mil beryllium foil with 5.7-Mev alpha particles.

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intensity of 7.6-Mev pairs therefore gives a limit of

$$\Gamma_{\pm e}/\Gamma_{\text{total}}<1.3\times10^{-4},$$

for the ratio of the partial width for pair emission to the total width of the 7.6-Mev state.

The 7.6-Mev state is known[2,3,9–11] to decay predominantly by alpha-particle emission. The partial width for alpha emission has been estimated[1,2] to be about 0.5 ev. If this is the case, then an upper limit of

$$\Gamma_{\pm e}<7\times10^{-5}\text{ ev}$$

is obtained for the partial width for pair emission of the 7.6-Mev state. This limit is consistent with the value of 4×10^{-5} ev estimated[1,2] from electron scattering experiments.

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Differential Cross Sections for Photodisintegration of the Deuteron at Far Forward and Backward Angles*

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Direct measurements of differential cross sections for photodisintegration of the deuteron have been made at center-of-mass angles of 11°, 100°, and 176° using photons with energies near 200 Mev.

The cross sections at 176° were found to be 3.8 ± 0.6 μbarns/sterad and 5.2 ± 0.6 μbarns/sterad at a mean photon energy of 190 Mev and 238 Mev, respectively. These cross sections are higher than would be predicted by extrapolation from the angular distributions measured by other workers. The cross sections at the other two angles were in satisfactory agreement with previous measurements or extrapolations of measurements.

The behavior of the differential cross sections at the far backward angle is taken as additional evidence of the close relation between photoproduction of mesons and photodisintegration of the deuteron in this energy region.

INTRODUCTION

THE following experiment was performed for the purpose of obtaining direct measurements of differential cross sections for photodisintegration of the deuteron at far forward and backward angles, at photon energies near 200 Mev.

Most of the previous data[1] concerned with the angular distributions for this process have been taken between the laboratory angles of 30° and 150°. Angular distributions were then assumed and extrapolation made to complete the plot of differential cross section *versus* center-of-mass angle at a fixed photon energy. The c.m. angular distribution laws often assumed for this purpose were

$$d\sigma/d\Omega^*=A+B\cos\theta^*+C\cos^2\theta^*, \quad (1a)$$

or

$$d\sigma/d\Omega^*=(A+B\sin^2\theta^*)(1-\beta\cos\theta^*). \quad (1b)$$

Although extensions of the existing measurements would have little effect on the total cross section, they could determine the validity of the above expressions or indicate the need for a more detailed theoretical approach.

EXPERIMENTAL PROCEDURE AND APPARATUS

Figure 1 shows the arrangement of the apparatus for the forward angle runs. The collimated 305-Mev bremsstrahlung beam strikes a 1-in. liquid deuterium

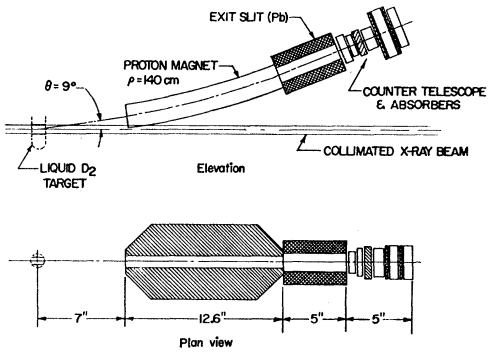

FIG. 1. Elevation view of the target, magnet, and counter telescope arrangement for the 11° c.m. measurement.

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