DETERMINATION OF THE DEUTERON D WAVE FROM COHERENT π^0 PHOTOPRODUCTION*

E. F. Erickson and C. Schaerf
High-Energy Physics Laboratory, Stanford University, Stanford, California
(Received 20 September 1963)

The elastic photoproduction of π^0 mesons in deuterium constitutes a way of measuring deuteron form factors independent of electron scattering. To obtain information on the integrals of the deuteron ^3S and ^3D wave functions from experimental data, the two methods require different theoretical assumptions. Electron scattering requires the knowledge of the electromagnetic structure of the nucleons and the radiative corrections. While the second problem does not present serious difficulties, little information is now available on the electric form factor of the neutron at high momentum transfer. Elastic π^0 photoproduction requires the knowledge of the photoproduction matrix elements, the use of the impulse approximation, and some hypothesis on the multiple scattering in the nucleus. A discussion of the approximations involved and the hypothesis introduced can be found in the articles of Hadjioannou,[1] and Friedman and Kendall.[2]

In this work, an extension of the one by Friedman and Kendall, we have measured the differential cross section for the elastic photoproduction of π^0 mesons in deuterium for an incident gamma-ray energy of 500 MeV. We have chosen the energy of 500 MeV because in this energy range the effect of the second pion-nucleon resonance is still negligible, and the pion-nucleon phase shifts are fairly well known. Moreover, the small value of the photoproduction matrix elements encourages one to neglect multiple nuclear scattering. This seems to be substantiated also by the measurements of Friedman and Kendall.

Figure 1 shows our results and the theoretical predictions. We have used the theory of Hadjioannou with some modifications calculated by Hearn to better account for the small phase shifts. The pion-nucleon phase shifts have been obtained by a linear interpolation of those reported by Pontecorvo.[3]

Two sets of deuteron wave functions have been assumed. One set was calculated by F. Partovi using Hamada's potential, and the other was calculated by R. G. Brandt, G. Breit, and H. M. Ruppel. Both functions have a 7% D wave, the correct value for the quadrupole moment, and give practically the same integrals in the momentum region in which we are interested. The solid lines represent the theoretical results with

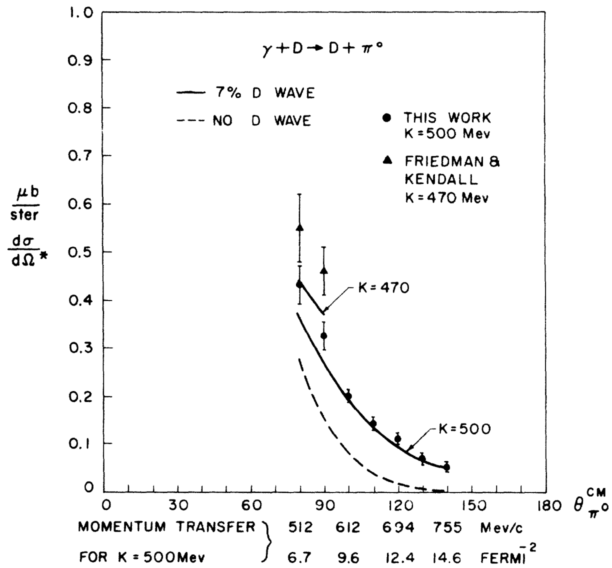

FIG. 1. Differential cross section in the center-of-mass system for the process $\gamma+d\rightarrow\pi^0+d$. The cross section is in microbarn/steradian. In abscissa we have indicated the angle in the center-of-mass system for the π^0 and the three-momentum transfer to the deuteron in MeV/c and inverse fermi squared.

a 7% D wave. The dashed line represents the theoretical prediction when the D-wave contribution has been neglected.

We can also analyze our data using the same theory and, neglecting all the other experimental information now available, consider the D-wave contamination as a free parameter. In this way, we can say that from our experiment alone the ^3D wave in the deuteron ground state is $(7.5\pm 0.6)\%$.

It is a pleasure to thank Professor W. C. Barber and Professor R. Hofstadter for their continuous encouragement and support. We are also very grateful to Professor J. Friedman, Professor H. Kendall, and Dr. A. Hearn for many useful discussions.

*Research supported in part by the joint program of the U. S. Office of Naval Research, and the U. S. Air Force Office of Scientific Research.

[1]F. T. Hadjioannou, Phys. Rev. 125, 1414 (1962).

[2]J. I. Friedman and H. W. Kendall, Phys. Rev. 129, 2802 (1963).

[3]B. Pontecorvo, Proceedings of the Ninth Annual International Conference on High-Energy Physics, Kiev, 1959 (Academy of Sciences, U.S.S.R., Moscow, 1960).