$C^{14}(p,\alpha)B^{11}$ Angular Distributions at $E_p=18$ MeV*

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Angular distributions are given for the ground state and first three excited states of B^{11} following the $C^{14}(p,\alpha)B^{11}$ reaction at an incident proton energy of 18.0 MeV. The results suggest a direct-interaction reaction mechanism but are not in agreement with the simple plane-wave theory for this mechanism.

THE angular distributions of the α particles from the $C^{14}(p,\alpha)B^{11}$ reaction for an incident proton energy of 18.0±0.1 MeV were measured for the ground state (α_0), 2.14-MeV level (α_1), 4.46-MeV level (α_2), and 5.04-MeV level (α_3) of B^{11}. The measurements were made in the 60-in. scattering chamber of the Princeton FM cyclotron using a silicon junction detector to detect the reaction particles. The over-all resolution of the silicon detector-amplifier system was about 65 keV for α particles, so that the resolution of the experiment was determined by the beam spread ($\approx$150 keV) and energy loss in the target ($\approx$300 keV).

The C^{14} target was prepared by electro-depositing acetylene made from $BaCO_4$ enriched to 80% in C^{14} onto a 2-mg/cm² gold backing.[1] The target was found to contain 0.25±0.02 mg/cm² of C^{12} and 0.13±0.02 mg/cm² of O^{16} by comparison of differential cross sections for the $C^{12}(p,p)C^{12}$, $O^{16}(p,p)O^{16}$, and $O^{16}(p,\alpha)N^{13}$ reactions with those obtained with a Mylar ($C_{10}H_8O_4$) target of known thickness. The total thickness of the C^{14} target was measured,[2] using the $C^{14}(p,n)N^{14}$ reaction to be 0.6±0.1 mg/cm², giving 0.22±0.1 mg/cm² for the C^{14} thickness. The C^{14} thickness was also determined by the $C^{14}(p,d)C^{13}$ reaction[3] giving an average value for the C^{14} thickness of 0.28±0.07 mg/cm².

A spectrum obtained at θ(lab)=30° is shown in Fig. 1. The α-particle groups corresponding to the first four levels of B^{11} are designated, as are α-particle groups due to the $C^{12}(p,\alpha)B^9$ and $O^{16}(p,\alpha)N^{13}$ reactions, and the deuteron group due to the $C^{14}(p,d)C^{13}$ (3.68-MeV level) reaction. The angular distribution of the $O^{16}(p,\alpha)N^{13}$ (ground state) reaction was measured using a Mylar target and was used to correct the $C^{14}(p,\alpha)B^{11}$ results for those angles at which the N^{13} (ground state) group overlapped with one or another of the B^{11} groups. The $O^{16}(p,\alpha)N^{13}$ (ground state) angular distribution was in

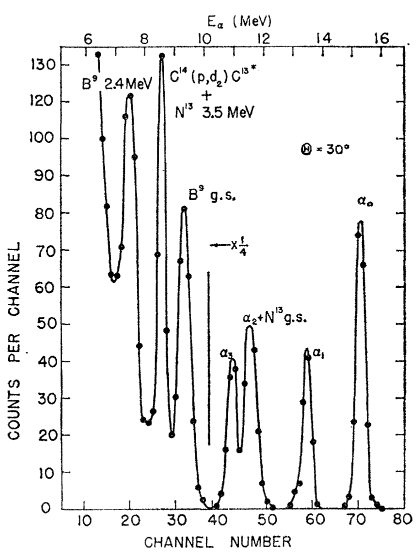

FIG. 1. Spectrum of particles detected by a silicon junction detector placed at 30° to an 18.0-MeV proton beam bombarding a C^{14} target. The α groups corresponding to the ground state and first three excited states of B^{11} from $C^{14}(p,\alpha)B^{11}$ are designated, as are particle groups due to the C^{12} and O^{16} impurities in the target.

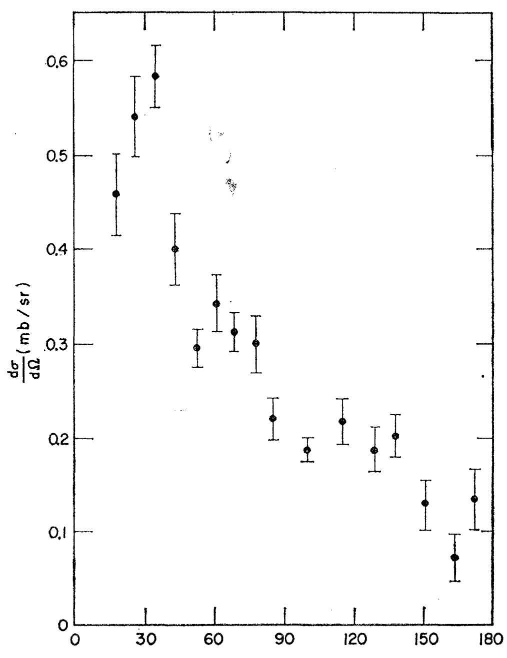

FIG. 2. Angular distribution in the center-of-mass system for the $C^{14}(p,\alpha)B^{11}$ (ground state) reaction for $E_p=18.0$ MeV.

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[1] The target was prepared by W. F. Moore and J. N. McGruer. We would like to thank Dr. Moore for sending the target to us.

[2] L. F. Chase, Jr., R. G. Johnson, F. J. Vaughn, and E. K. Warburton, Phys. Rev. 127, 859 (1962).

[3] J. C. Legg, Princeton University thesis, 1962 (unpublished).

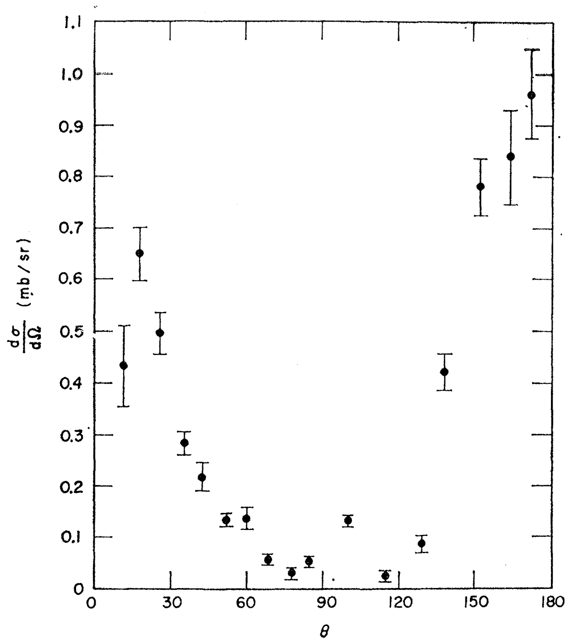

FIG. 3. Angular distribution in the center-of-mass system for the $C^{14}(p,\alpha)B^{11}$ (2.14-MeV level) reaction for $E_p = 18.0$ MeV.

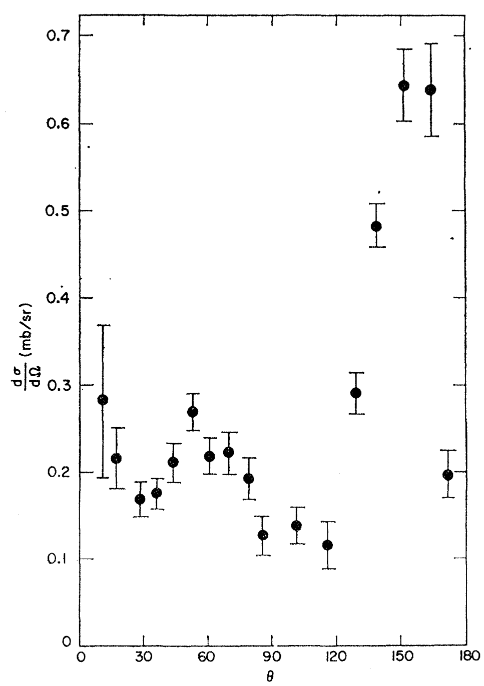

FIG. 4. Angular distribution in the center-of-mass system for the $C^{14}(p,\alpha)B^{11}$ (4.46-MeV level) reaction for $E_p = 18.0$ MeV.

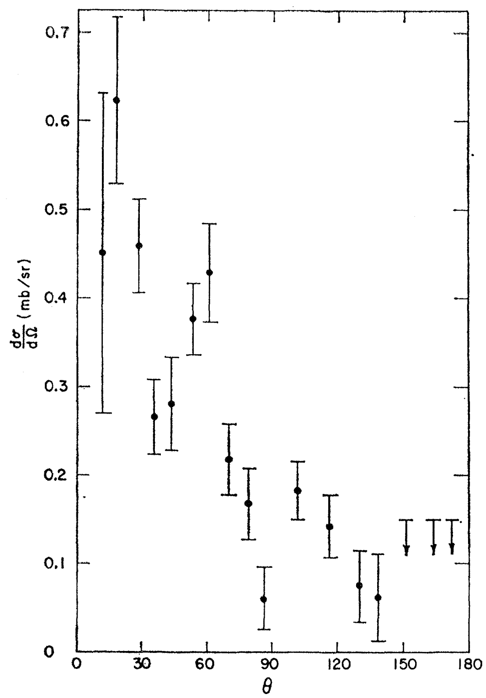

FIG. 5. Angular distribution in the center-of-mass system for the $C^{14}(p,\alpha)B^{11}$ (5.04-MeV level) reaction for $E_p = 18.0$ MeV. Upper limits are indicated for the measurements at the three highest angles.

good agreement with that obtained by Maxson[4] at $E_p = 18.1$ MeV.

The angular distributions obtained for the $C^{14}(p,\alpha)B^{11}$ reaction are shown in Figs. 2 through 5, where the angles and cross sections refer to the center-of-mass system. The cross-section scale in these figures has an uncertainty of 30%.

It is evident that these distributions do not agree with the simple (without exchange) plane-wave form of the direct-interaction theory which predicts angular distributions which go essentially as $j_L^2(qR)$, where L is the transferred orbital angular momentum, q the momentum transfer, and R the nuclear radius. In particular, the intense backward peaks in the distributions for the B^{11} 2.14- and 4.46-MeV levels cannot be explained by the simple theory. It would be of interest to see whether these angular distributions could be explained by the distorted-wave Born approximation form of the direct-interaction theory of the (p,α) reaction or whether it is necessary to include the exchange (i.e., heavy-particle stripping) term to obtain agreement with experiment.

[4] D. R. Maxson, Phys. Rev. **123**, 1304 (1961).