THE ANGULAR DISTRIBUTION OF NEUTRONS FROM THE REACTION C^{13} *(α, n)* O^{16}

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SCHIFFER, Kraus, and Risser[1] have reported a measurement of the angular distribution of neutrons from the reaction $C^{13}(\alpha, n)O^{16}$. Measurements were made for four α-particle energies (E_α = 2.69; 2.83; 4.42 and 4.63 Mev). The final nucleus O^{16} is formed in its ground state. Furthermore, the angular distribution changes slowly as the energy of the incident α particles is varied; there are strong forward and backward peaks. All these facts suggest that the reaction is due to direct interaction. Upon colliding with a C^{13} nucleus, the α particle need not penetrate inside, but instead can "knock out" a neutron and itself be absorbed into the remaining C^{12} nucleus (in analogy with (p, n) reactions). Another process is also possible. The C^{13} nucleus can be pictured as an "asymmetric deuteron." In the collision with an α particle, the neutron can be emitted in analogy with a (d, n) reaction. Owen and Madansky[2] have used this last model in their investigation of the reaction $Be^9(\alpha, n)C^{12}$. It is clear that in the first-mentioned process, most of the neutrons will have momenta parallel to the velocity of the incoming α particles, while in the second process most of the neutrons will have momenta antiparallel.

Using Butler's results[3] to calculate the differential cross section for the "knock-on" process and those of Owen and Madansky for the second process, the following formula for the differential cross section of the reaction $C^{13}(\alpha, n)O^{16}$ can be derived:

$$\frac{d\sigma}{d\Omega} = \frac{A_1}{(K_1^2 + 3.05)^2}\left(\frac{1.77}{K_1}\sin K_1R_1 + \cos K_1R_1\right)^2 + \frac{A_2}{(K_2^2 + 0.24)^2} j_0^2(k_2R_2),$$

This formula assumes that the two processes do not interfere with each other. j_0 is the spherical Bessel function of zero order; R_1 and R_2 are characteristic radii (in units of 10^{-13} cm); and furthermore we have

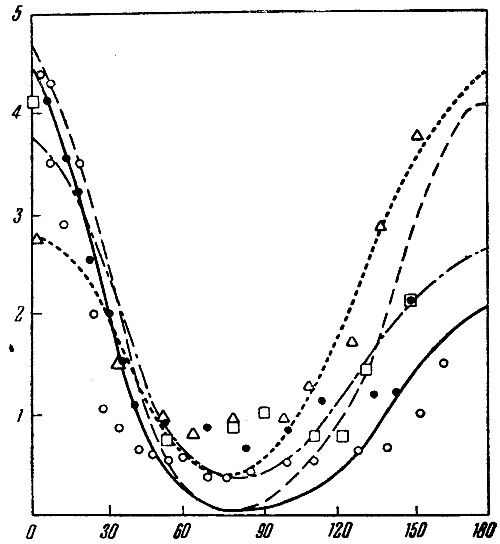
$$K_1 = \sqrt{k_\alpha^2 + k_n^2 - 2k_nk_\alpha\cos\vartheta},$$

$$k_2 = \sqrt{k_\alpha^2 + 0.06k_n^2 + 0.50k_\alpha k_n\cos\vartheta},$$

$$K_2 = \sqrt{k_n^2 + 0.01k_\alpha^2 + 0.16k_\alpha k_n\cos\vartheta}.$$

Under the square root signs, the k's are the wave numbers of the corresponding particles in units 10^{13} cm^{-1}, while θ is the scattering angle in the center of mass system. The constants A_1 and A_2 can be determined independently, since the amplitudes for the two processes do not overlap. The table shows the numerical values assigned various parameters in the calculation. The resulting, calculated angular distributions are shown in the figure, together with the experimental data.[1] (The spin of C^{13} was taken to be $\frac{1}{2}^-$, that of O^{16}, O^+ and of He^4, O^+; the odd neutron in C^{13} was taken to be in an S-state. In both processes, the angular momentum absorbed is zero.)

E_α, Mev	k_α	k_n	R_1	R_2
2.69	0.57	0.46	3.5	4.5
2.83	0.59	0,47	3.5	4.5
4.42	0.74	0.53	3.5	4.0
4.63	0.75	0.53	3.5	4.0



Neutron angular distributions. □ and the dash-dot line – E_0 = 2.69 Mev; Δ and the dashed line – E_0 = 2.83 Mev; ● and the dotted curve – E_0 = 4.42 Mev; ○ and the continuous curve, – E_0 = 4.63 Mev.

[1] Schiffer, Kraus, and Risser, Phys. Rev. **105**, 1811 (1957).

[2] L. Madansky and G. Owen, Phys. Rev. **99**, 1608 (1955).

[3] S. T. Butler, Phys. Rev. **106**, 272 (1957).

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