Angular Distribution of Protons from Vanadium 52†

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Angular distributions have been obtained for the protons from the ground and first excited states for the reaction $V^{51}(d,p)V^{52}$. The results indicate that the captured neutron carries in mainly one unit of orbital angular momentum for both states. The 29th neutron is thus presumed to be a $p_{\frac{3}{2}}$ nucleon.

IN two previous letters[1] the angular distributions of protons from the reactions $P^{31}(d,p)P^{32}$ and $Cl^{37}(d,p)Cl^{38}$ were reported. The results were in good agreement with the predictions of the shell model.[2] As a continuation of this study, angular distributions of the protons from the reaction $V^{51}(d,p)V^{52}$ have been obtained for the ground and first excited states of V^{52}. The data are plotted in Figs. 1 and 2 along with the calculated Butler curves for the ground state and first excited state, respectively. The measured Q values were 5.0 and 4.2 Mev, respectively, in close agreement with the values 5.02 and 4.23 Mev reported by Harvey.[3] The theoretical curves were computed for $l_n=1$ and 3 using a value of $r_0=6.3\times10^{-13}$ cm for both states. The mid-foil incident deuteron energy was 7.05 Mev in the c.m. system. The target consisted of a foil of pure vanadium 0.375 mil thick. The vertical lines through the experimental points represent only the uncertainty due to the total number of counts.

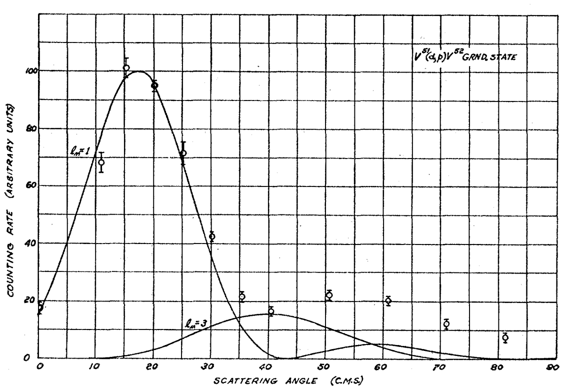

FIG. 1. The angular distribution of the protons associated with the ground state in the reaction $V^{51}(d,p)V^{52}$. The solid curves are calculated from the Butler theory using $r_0=6.3\times10^{-13}$ cm.

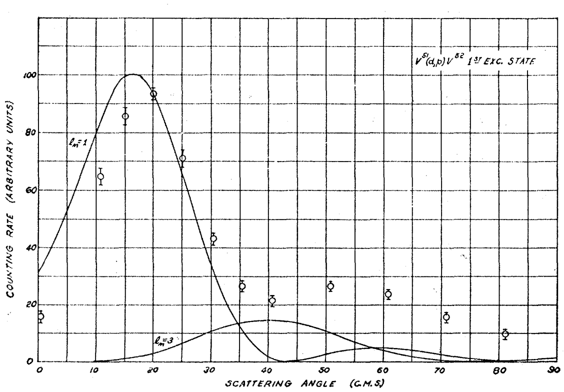

FIG. 2. The angular distribution of the protons associated with the first excited state of V^{52}. The solid curves are calculated from the Butler theory using the same r_0 as for the ground state.

At small angles the data for the ground state of V^{52} fit reasonably well the calculated curve for $l_n=1$. From this one might conclude that the captured neutron carries in one unit of orbital angular momentum and that the 29th neutron in V^{52} is a $p_{\frac{3}{2}}$ nucleon. However, since the relative amplitude of the $l_n=3$ peak is about one-seventh that for $l_n=1$, one cannot rule out the possibility of considerable admixture. It is difficult to make a reliable estimate of the admixture in view of the uncertain "background" rising from other competing processes. In addition most experimental data on angular distributions at these energies are characterized by the fact that the cross sections do not go to zero at the first minimum as might be expected from Butler's calculation. While it is quite possible that further refinements of the theory will bring about better agreement[4] with experiment, on the basis of the present data it would appear that 25 percent of $l_n=3$ would represent an upper limit. Any additional admixture removes the minimum occurring at 40°.

As pointed out by Bethe and Butler,[2] the levels for the shell starting with the 29th nucleon are closely spaced, hence one might expect the 29th neutron to be either a $p_{\frac{3}{2}}$ or an $f_{\frac{5}{2}}$ particle. The selection rules allow $\Delta l=1$, 3, 5 and possibly 7. Although one cannot, on the basis of the data here presented, eliminate a sizable percentage of $l_n=3$ it is probable that it is a $p_{\frac{3}{2}}$ nucleon.

The neutron accepted into the first excited state also appears to carry in mainly one unit of orbital angular momentum (Fig. 2). Although the data appear to be shifted toward larger angles, it clearly does not fit an $l_n=2$ curve. A slightly different value of r_0 results in better agreement. A third level ($Q=3.4$ Mev), presumably the second excited state of V^{52}, also corresponds to the capture of an $l_n=1$ neutron.

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[1] Parkinson, Beach, and King, Phys. Rev. 87, 387 (1952); J. S. King and W. C. Parkinson, Phys. Rev. 88, 141 (1952).
[2] H. A. Bethe and S. T. Butler, Phys. Rev. 85, 1045 (1952).
[3] J. A. Harvey, Phys. Rev. 81, 353 (1951).
[4] See, for example, P. B. Daitch and J. B. French, Phys. Rev. 87, 900 (1952); and Bhatia, Huang, Huby, and Newns, Phil. Mag. 43, 485 (1952).