energy theory will extend the excellent recent interpretation of thermal neutron cross sections by Rosenzweig,[6] Bloch,[8] and Ross.[9] Particle spectra from highly excited nuclei are currently being interpreted with a more elaborate theoretical treatment in order to arrive at the shape of the nuclear potential.

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CAPTURE GAMMA RAYS FROM O^{15} AND O^{16} IN THE REGION OF THE GIANT RESONANCE*

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Measurements of the 90° yield ground-state γ rays resulting from the capture of protons into the giant resonance region of O^{15} and O^{16} have been using the Princeton FM cyclotron. This Letter reports principally the results of the reaction $N^{15}(p,\gamma)O^{16}$ ($Q = 12.11$ Mev).

The reaction $N^{15}(p,\gamma_0)O^{16}$ is the inverse of the reaction $O^{16}(\gamma,p_0)N^{15}$ where γ_0 and p_0 represent transitions to the ground state of the residual nucleus. The latter reaction has been studied by several authors[1-3] in the region of the giant resonance using the bremsstrahlung continuum as a source of high-energy photons. A detailed study of the giant resonance region of O^{16} is more readily made from the inverse process $N^{15}(p,\gamma_0)O^{16}$ using protons with a well-defined energy. The results of such a study are reported in this Letter for the region of excitation in O^{16} between 21 and 26 Mev. A detailed study of photodisintegration of O^{16} in this energy region has a particularly direct bearing on the understanding of the giant resonance phenomenon because the closing of the $1p$ shell at O^{16} allows a relatively explicit theoretical treatment to be made for this nucleus. Elliott and Flowers[4] have calculated the properties of the $J^{\pi} = 1^-$, $T = 1$ states arising from the $p^{-1}d$ and $p^{-1}2s$ configurations in O^{16}. These states are responsible for electric dipole absorption from the O^{16} ground state and should give rise to the giant resonance according to the Wilkinson[5] model which explains the giant resonance in terms of single-particle excitations of the ground state. Elliott and Flowers found their calculations to be in substantial agreement with previous[1,2] investigations of the $O^{16}(\gamma,p)N^{15}$ reaction so that it is of interest to test their shell-model predictions more fully.

The experimental details will be given in a fuller report of this investigation; only a brief description is given here. The external proton beam from the Princeton FM cyclotron was reduced in energy with polyethylene absorbers to extend the range of variability of the proton beam energy from its unattenuated range of 14.5 to 19.5 Mev, so as to cover the range of the giant resonance, 9.5 to 15 Mev. The beam passed through a cylindrical gas cell $1\frac{1}{2}$ in. long, $\frac{3}{8}$ in. in diameter, which contained N^{15} gas at a pressure of 930 mm Hg. The end windows of the cell were of 0.0005-in. Mylar sheet. The N^{15} gas used has an isotopic purity of 98.7%. Gamma radiation from the target was detected in a 3 in.×3 in. NaI crystal 7 cm from the center of the target, and the pulses were analyzed in a 200-channel analyzer gated on only for the duration of the cyclotron beam pulse. To minimize the effect of pulse pile-up in the counter, the current pulses from the photomultiplier were delay-line clipped to 0.2 μsec, and all pulses corresponding to an energy less than 10 Mev were eliminated at this stage by a biased transistor preamplifier. The larger pulses, passed by the biased preamplifier, were lengthened and fed to the analyzer.

Measurements were made at 29 proton energies. The beam current varied with energy, being about 3×10^{-5} μa at the lowest proton energy with the thicker absorber (9.5 Mev) and about 2×10^{-4} μa at higher energies. Measurements were made for a constant integrated beam current of 0.75 microcoulomb.

The transition to the ground state stood out clearly at the highest energies. The next highest energy radiation present was that leading to the O^{16} excited states at ~6 Mev. In analyzing the data for the variation of cross section with energy, the counts contained within a range of 4.5 Mev of the maximum energy were included, and a background was subtracted on the assumption that the flat background observed at higher energies continued in the same way back into this region.

The variation of the 90° γ-ray yield with excitation energy in O^{16} is shown in Fig. 1. The differential cross section has been computed using a net efficiency for the NaI crystal of 0.25% at $E_\gamma = 22$ Mev. If it is assumed that the γ rays have an isotropic distribution relative to the proton beam, the ordinate scale of Fig. 1 gives the total cross section. The $N^{15}(p,\gamma_0)O^{16}$ results show two large resonances peaked at 21.8 and 24.7 Mev, respectively. There are strong indications of some detailed structure in the higher resonance. The peak energies are in striking agreement with the Elliott and Flowers calculations which predict $J^\pi = 1^-$, $T = 1$ levels at 22.6 and 25.2 Mev. Elliott and Flowers calculated the γ widths of the 22.6- and 25.2-Mev states to be in the ratio 1:2. From Fig. 1 it is seen that the present results are in qualitative agreement with this prediction, assuming that Γ/Γ_p is approximately the same for the two resonances, and would seem to give strong support for the single-particle model of the giant resonance, at least for the lighter nuclei.

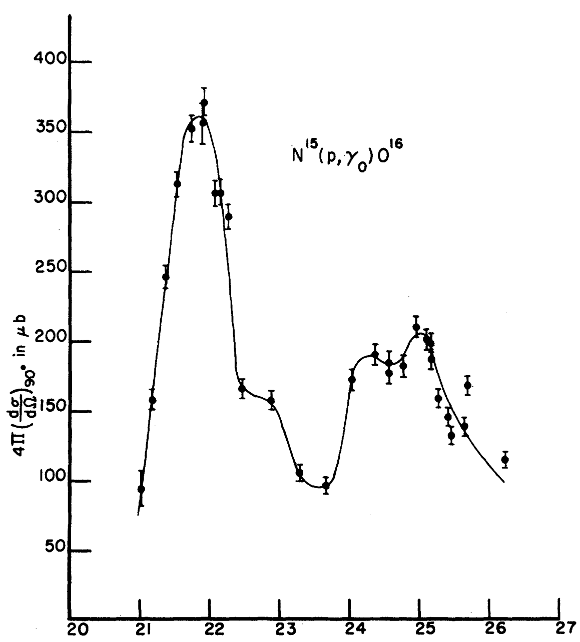

FIG. 1. The 90° yield of γ rays leading to the ground state of O^{16} from the $N^{15}(p,\gamma)O^{16}$ reaction. If the γ rays have an isotropic distribution relative to the proton beam, the ordinate scale gives the total cross section.

The experimental arrangement used to investigate the $N^{14}(p,\gamma_0)O^{15}$ reaction ($Q = 7.30$ Mev) was similar to that described above except that a self-supporting melamine target of 4.9-mg/cm^2 thichness was used for the target; however, the results obtained are quite different from those obtained from $N^{15}+p$. For O^{15} excitation energies between 19 and 25 Mev the 90° yield of γ_0 was essentially constant with

$$4\pi\,(d\sigma/d\Omega)_{90°} \simeq 30\,\mu\text{b}.$$

This region of excitation in N^{15} (the mirror nucleus to O^{15}) has been studied by the $N^{15}(\gamma,p_0)C^{14}$ reaction.[6] The results indicate a narrow ($\Gamma \lesssim 500$ kev) resonance at ~20.5 Mev in N^{15} superimposed on a flat background. A possible reason why this resonance was not seen in the $N^{14}(p,\gamma_0)O^{15}$ reaction could be that it has $T = 3/2$, in which case it could not be formed by $N^{14}+p$.

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