data of Table I, it may be seen that groups of 6-kev separation or more could have been resolved. It may also be seen that any isolated group with an intensity of approximately 2 percent of the ground-state fluorine group would have been detected; and furthermore, with the range of bombarding energies used, there exist no gaps in the excitation of F^{19} in which a state could be hidden by a contaminant group.

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Yield of High-Energy Gamma Rays from Proton Capture in Be^9

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Two yield curves have been taken for gamma rays of energy above 2.5 Mev and 5.6 Mev respectively, with proton energies from 150 kev up to 518 kev. The curve for gamma rays above 2.5 Mev shows a single broad resonance around 330-kev proton energy. After correction for barrier penetration the curve can be fitted by a Breit-Wigner formula with resonance energy 307 kev (corresponding to a level in B^{10} at 6.86 Mev) and with half-width 160 kev. The curve for gamma rays above 5.6 Mev also shows a nonresonant radiation, which consists of more energetic components.

The yield of gamma rays from proton capture in beryllium has been investigated by Curran *et al.*,[1] by Hole *et al.*,[2] and by Hunt.[3] They all found a broad resonance around 340-kev proton energy, but Hunt observed another broad resonance of even higher yield, around 489 kev, while Hole obtained constant yield between 430 and 500 kev.

Trying to find the reason for this discrepancy, we have measured the gamma-ray yield between 150 and 520 kev with protons from our 0.5-Mev Van de Graaff machine. The gamma-ray detector was a NaI-scintillation counter.

First the yield was measured with the discriminator bias set to count only gamma quanta of energy above 2.5 Mev. In this way gamma counts from carbon contamination of the target were eliminated. Our targets were contaminated with fluorine during evaporation, but the sharp resonance at 340 kev could easily be singled out. The result is given in Fig. 1, curve I. The curve agrees well with reference 2 and shows no indication of the 489-kev resonance reported by Hunt.

Curve II shows the experimental yield after correcting for finite target thickness (10 kev at 300-kev proton energy) and taking into account the barrier penetration factor for *s*-wave protons according to Christy and Latter.[4] Curve III is calculated from the Breit-Wigner formula, with resonance energy 307 kev and half-width 160 kev. There is little evidence here for a resonance below 150 kev, but the disagreement with the calculated curve of Tangen[2] is chiefly due to the use of a different penetration factor. In the region 450 to 500 kev, however, the corrected yield is about twice the calculated yield from a single resonance at 307 kev.

Curve IV is the yield curve with the discriminator set to accept only quanta above 5.6 Mev. In this curve

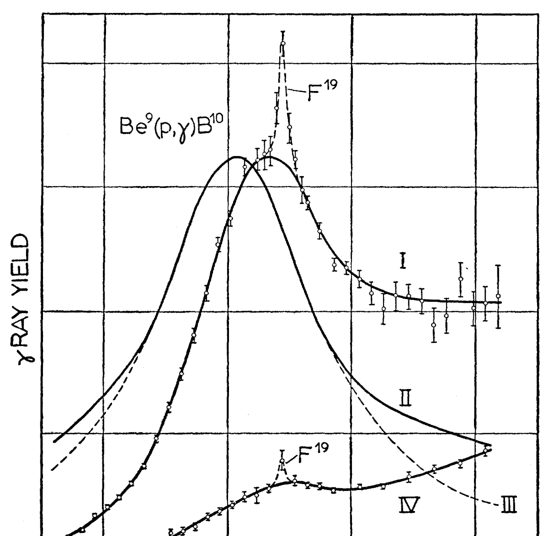

Fig. 1. Yield of gamma rays from proton capture in beryllium. Curve I: Experimental curve, gamma energy above 2.5 Mev. Curve II: Corrected for target thickness and barrier penetration. Curve III: Calculated from Breit-Wigner formula. $E_R=307$ kev, half-width 160 kev. Curve IV: Experimental curve, gamma energy above 5.6 Mev.

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the radiation from the 330-kev resonance is suppressed strongly, showing that most of this radiation has energies lower than 5.6 Mev, in accordance with measurements of Carlson and Nelson.[5] The curve also shows that the radiation has a component of high-energy gamma rays, having a yield curve that rises smoothly through the whole region.[6] It is evident that a great part of the high-energy quanta observed by Carlson and Nelson belongs to the nonresonant part of curve IV.

Carlson and Nelson[5] have measured the gamma spectrum at a proton energy of 315 kev, and found that 8 percent go to the ground state, 20 percent to the first excited level, and the rest to still higher levels. The quanta going to the first excited level (gamma energy approximately 6.15 Mev) would contribute to curve IV, but because of the discriminator setting their efficiency would be greatly reduced compared to that for quanta from transitions to the ground state. Pulses resulting from transitions to still higher levels would be completely suppressed.

Jacobs *et al.*[7] have found that the gamma radiation is isotropic. They used G.M. tubes, which means adding the effect of all different transitions. The distribution from one specific transition could still be anisotropic. We have measured the yield in one case at two different angles, relative to the direction of the proton beam. Curves I and IV are observed at 0°. With the same discriminator setting as in curve IV (5.6 Mev), we have observed the yield at 90° and, within the limits of error, have got the same ratio between the yields at 330 kev and at 500 kev. Therefore, if the angular distribution is not isotropic, at least it must be approximately the same for the two transitions contributing in this case.

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[6] After this manuscript was written we extended the measurements of curve IV up to 550 kev with our new Van de Graaff machine. There is still a continuously increasing yield, and no indication of the resonance at 489 kev reported by Hunt.[3]
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Differential Elastic Scattering Cross Section for Neutrons on Nitrogen

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Two independent methods were used to measure the angular distribution for elastic scattering of neutrons from nitrogen in the neutron energy range from 0.80 to 2.36 Mev. The scattered neutrons were counted directly in order to obtain the absolute differential cross section at four neutron energies. These curves provide information on the potential scattering for energies below 1.54 Mev. The second technique, which observed the recoil nitrogen nuclei, allowed a study of scattering at the resonances. In this manner parities were established for levels in N^{15} as follows: The 1.120, 1.401, 1.595, and 2.25-Mev levels have odd parity; the 1.779-Mev level has even parity and a tentative assignment of even parity was made for the 1.350-Mev level. J-values associated with resonances at 1.12 and 2.25 Mev were each assigned to be 3/2 rather than the values favored in the literature.

I. INTRODUCTION

It has been recognized for a long time that differential elastic scattering neutron measurements yield valuable information about nuclear structure and resonance parameters. The differential scattering of 1-Mev neutrons from heavier elements[1] has been used as a test of the cloudy crystal ball model of the nucleus.[2] In this laboratory we have begun a systematic study of the resonance scattering of neutrons from light nuclei.[3–5] Nitrogen is an appropriate nucleus for such studies. There are a number of levels at relatively low energies[6–9] so that one can accumulate information as to how the quantum properties vary from level to level. In general the levels have sufficient width (~20 kev) so that one can resolve them with standard techniques. The reaction cross sections of both (n,p) and (n,α) reactions are known[10–12] so that a comparatively complete theoretical analysis of the scattering process can be made. In the 2.6- to 4.2-Mev energy region measurements

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