A 1 in. high by 7/16 in. wide rectangular hole was cut between the parallel flat faces of a 2 in. diameter × 2 in. long cylindrical NaI(Tl) crystal. A bar of magnesium metal was placed within this well and the crystal was mounted on an RCA 6342 phototube. The resultant scintillation counter had a pulse height resolution (for direct radiation) of 10% at 1.38 Mev. A lead collimator limited the gamma rays entering this crystal to those which are scattered from the magnesium bar in the center. A differential analyzer was set to accept a narrow range of pulses above the center of the 1.38-Mev photopeak. Thus pulses due to Compton scattering from the magnesium were largely eliminated.

The coincidence rate was observed as a function of angle over a small range of angles centered at 120°. A sharp peak was observed, which, within the limits of experimental error, had an angular width as narrow as that of the collimating system (2.6° as measured by annihilation radiation). The coincidence rate at the peak was consistently two or three times the rate measured at neighboring angles off the peak (depending mainly on the sharpness of the pulse height discrimination).

Since the observed resonance effect was so large, it was possible to perform a self-absorption experiment[3] in order to measure the resonance scattering cross section. The coincidence rate was observed as a function of angle as an aluminum and a magnesium absorber were alternately inserted between the source and the resonance scattering detector. In this way it was possible to calculate the selective attenuation of the resonance radiation by the magnesium absorber. The ratio of the coincidence rates on resonance ($\theta = 120°$) to off resonance ($\theta = 114°$) for a magnesium absorber of 1.96 cm thickness was found to be 1.39 ± 0.26. For an aluminum absorber which attenuated the off-resonance coincidence rate by an amount similar to the magnesium absorber, the ratio of the coincidence rates at 120° and 114° was found to be 2.03 ± 0.3. The level width then follows from the attenuation upon inclusion of the dependence of the resonance effect on the spins involved and the thermal Doppler width. Preliminary data indicate a level width of 7×10^{-4} ev. This corresponds to a mean life of $\tau_\gamma = 0.95\times10^{-12}$ sec for the 1.38-Mev level. The statistical uncertainty in these measurements is about 90%. Helm[4] has estimated the mean life of this level from electron scattering data. His value, $\tau_\gamma = 1.9\times10^{-12}$ sec, is probably correct to within one order of magnitude and agrees well with the present work.

Experiments are continuing in order to improve the precision of the data and to study the apparent absence of beta recoil effects. A complete report will be published as soon as the measurements are concluded.

It is a pleasure to acknowledge our indebtedness to R. R. Lewis for many helpful discussions.

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POLARIZED NUCLEONS FROM THE PHOTODISINTEGRATION OF THE DEUTERON

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In a series of previous publications the polarization of the nucleons from the D(γ, n)p reaction was calculated.[1,2] It was shown that, for unpolarized γ rays, the polarization $P(\theta)$ is rather sensitive to the final state interactions. The most important transitions are, in order of importance, $E1(^3S_1 + {}^3D_1 \to {}^3P_{0,1,2} + {}^3F_2)$, $M1$ spin flip ($^3S_1 \to {}^1S_0$ and $^3D_1 \to {}^1D_2$), and $E2(^3S_1 + {}^3D_1 \to {}^3S_1 + {}^3D_{1,2,3} + {}^3G_3)$. The $E1$ transition amplitudes are rather well known from the analysis of the angular distribution and total cross section.[3,4] The forthcoming experiments on $P(\theta)$ should provide most important information on the relatively less known $M1$-transition amplitudes. The lack of symmetry of $P(\theta)$ about 90° provides additional information on the spin-dependent n-p forces.

The rather impressive success of the two-nucleon potential of Signell and Marshak[5] was recently extended by De Swart and Marshak[3] to the photodisintegration of the deuteron. It was shown that agreement with the experimental data in the medium energy range could be obtained without renouncing the Siegert theorem by assuming as the final state interaction the Signell-Marshak potential and assuming for the deuteron about 7% D-state probability. This high-percentage D state is not in contradiction with the observed magnetic moment and quadrupole moment of the deuteron. It was the aim of the present note to study $P(\theta)$ under these very same assumptions.

The angular distribution in the photodisintegration can be written as[2]

$$d\sigma/d\Omega = a(1 \pm \beta_1 \cos\theta) + b\sin^2\theta(1 \pm \beta_2 \cos\theta). \qquad (1)$$

The + sign (- sign) refers to the proton (neutron). Here θ is the angle between the direction $\vec{k}/k$ of the observed particle and the direction $\vec{\kappa}/\kappa$ of the incoming γ ray in the center-of-mass system, $\vec{\kappa}$ is the relative momentum of the γ ray, and $\vec{k}$ is the relative momentum of the observed particle. The polarization $P(\theta)$ below refers to the $\vec{n} = \vec{\kappa}\times\vec{k}/|\vec{\kappa}\times\vec{k}|$ direction.[6] We can write[2]

$$(d\sigma/d\Omega)P(\theta) = \sin\theta[\gamma_0 + \gamma_1\cos\theta + \gamma_2\cos^2\theta], \qquad (2)$$

where the γ_i's can be directly expressed in terms of the transition amplitudes and the phase shifts. There is a difference between the proton and neutron case so that we must distinguish between $\gamma_i(p)$ and $\gamma_i(n)$. The coefficients a, b, β_1, β_2, and γ_i were calculated numerically[4] using the Gartenhaus wave function[7] for the deuteron and the S.M. potential for the final state interactions. We have calculated the $E1$-$E1$, $E1$-$E2$, $E1$-$M1$ spin flip and $E2$-$M1$ spin flip interference terms, taking the tensor coupling of the final states exactly into account. The results are given in Table I. The proton polarization at γ-ray energies in the laboratory of 9.3 Mev, 22.5 Mev, and 80.4 Mev are shown in Fig. 1.

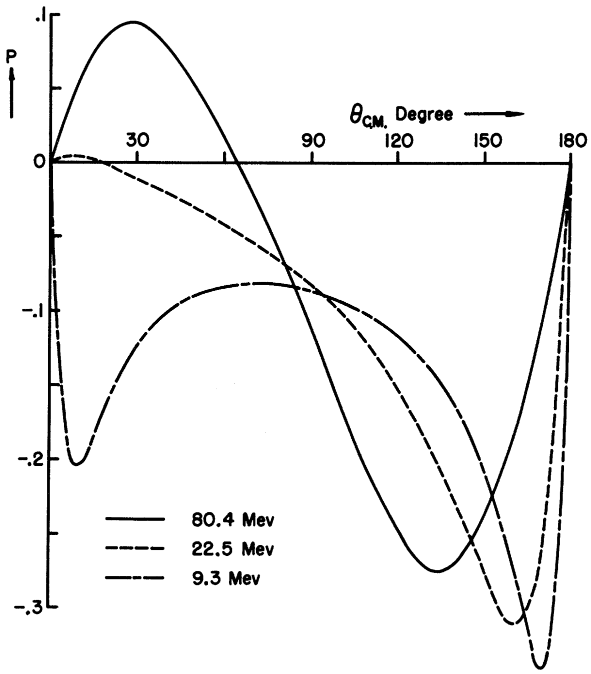

FIG. 1. Polarization of the protons for γ-ray energies in the lab of 9.3 Mev, 22.5 Mev, and 80.4 Mev.

At low energies the polarization is chiefly determined by the large γ_0 and the large b. This results in the characteristic saddle shape with two maxima at about 10° and about 170°. The polarization is negative.[8] The forward maximum

Table I. Summary of results. a, b, and the γ_i's are in μb/sterad.

E_γ lab (Mev)	9.3	11.3	22.5	40.6	53.7	80.4
a	4.45	4.22	4.46	4.89	4.87	4.54
b	171.5	135.7	49.3	16.7	9.39	4.35
β_1	0.04	0.05	0.10	0.13	0.13	0.14
β_2	0.18	0.20	0.32	0.47	0.57	0.70
$\gamma_0(p)$	-15.4	-11.6	-4.46	-2.18	-1.62	-1.02
$\gamma_0(n)$	-15.2	-11.5	-4.42	-1.87	-1.27	-0.58
$\gamma_1(p)$	2.16	2.8	3.87	3.38	2.84	1.97
$\gamma_1(n)$	4.61	4.9	4.68	3.48	2.65	1.84
$\gamma_2(p)$	0.43	0.43	0.86	0.79	0.66	0.80
$\gamma_2(n)$	-0.43	-0.43	-0.86	-0.79	-0.66	-0.80

decreases rapidly as the energy increases due to the decrease of γ_0. At about 20 Mev γ_0 and γ_1 are of the same order of magnitude and the forward maximum has totally disappeared. As the energy increases still more, γ_1 becomes larger than γ_0 and at the same time γ_2 comes into play. We get again a forward maximum. The forward polarization, however, is now positive. The backward maximum decreases slightly and shifts to somewhat smaller angles as the energy increases. In Fig. 2 the polarization of the proton as well as of the neutron is given for 80.4-Mev γ rays.

The difference between the proton and neutron polarization at lower energies is mainly due to the $M1$-$E2$ interference and at higher energies mainly to the $E1$-$E2$ interference. The neutron polarization is more negative (less positive) at small angles and less negative at large angles. The maximum difference occurs near the maxima of the polarization and is 2% at 9.3 Mev, 5% at 22.4 Mev, and 7% at 80.4 Mev.

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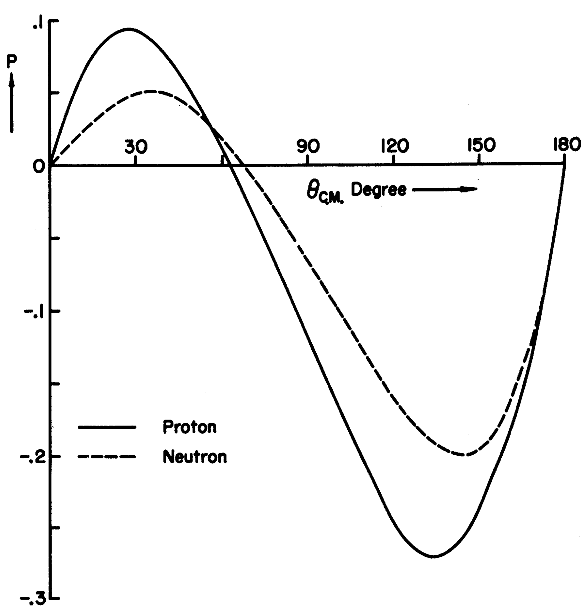

FIG. 2. Neutron and proton polarization at γ-ray energy in the lab of 80.4 Mev.

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ELECTRON DECAY OF THE POSITIVE PION*

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In a previous communication[1] from this laboratory an unsuccessful search for the electronic decay mode of the pion was reported which made it seem unlikely that the branching ratio $f=(\pi\rightarrow e+\nu)/(\pi\rightarrow\mu+\nu)$ could be much larger than 2×10^{-5}. The remarkable success of the A-V theory[2,3] in accounting correctly for many related phenomena had raised doubt about our failure to observe this process. Accordingly, we decided to make a new attempt, and this effort was accelerated when we learned of the successful observation of the electronic mode by the CERN group[4] and by Steinberger.[5]

Our new work confirms the existence of the π-e mode in an amount not very different from the value 1.28×10^{-4} predicted by the universal A-V theory (without radiation correction).[6] We also know that additional confirmations have been obtained from experiments similar to ours which are in progress at Stanford[7] and Berkeley.[8] We