anomalous effects may be considerably quenched in heavy elements.

Classically, the large backward scattering can be explained by attributing a frequency-dependent magnetic susceptibility to the nucleons with a resonance at the meson absorption peak. The parameters of such a resonance can be determined from the total magnetic dipole absorption of a deuteron at meson resonance and from the resonant half-width. The ratio of 135° to 90° scattering predicted by this simple model is in agreement with the experiment.

The apparent reduction in scattering at 90° could be attributed to a large radius ($R_0=1.3$ for C; $R_0=1.6$ for Be) for light elements, and/or to the electric susceptibility of the nucleons. A classical resonance calculation for electric dipole meson production predicts a reduction in the 90° cross section comparable with what is observed.

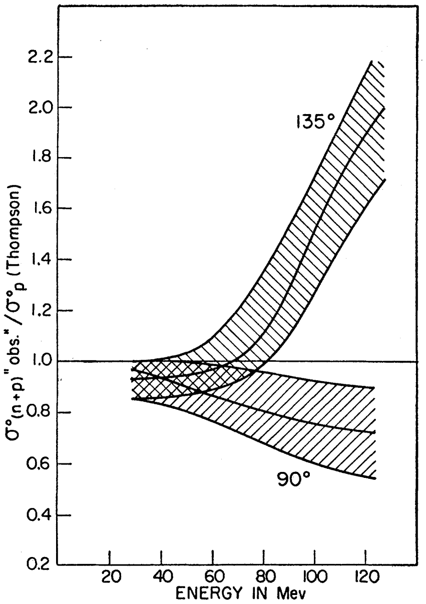

FIG. 2. Ratio of the "neutron+proton" γ-ray cross section "observed" in Be and C to the classical proton Thompson cross section.

Thus far, no experiments have been done to separate neutron and proton effects on the scattering cross section. In view of the alleged charge independence of photomeson reactions, it seems reasonable that both contribute equally to the anomalous scattering. That is why a deuteron was used in the calculation of magnetic dipole oscillator strength.

A more sophisticated phenomenological calculation for protons just received from Gell-Mann, Goldberger, and Thirring is likewise in agreement with the data, provided that only protons give anomalous effects. If the neutrons contribute comparably to the anomalous scattering, then their scattering amplitudes seem to be a factor of two larger than fits the data. This disagreement may indicate some quenching of meson effects in complex nuclei. However, more accurate data, including probably a hydrogen-deuterium comparison, is necessary before such conclusions can be drawn experimentally.

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Small-Angle Neutron-Proton Scattering at 400 Mev*

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THE previously reported[1] differential *n-p* scattering measurements at 400 Mev have now been extended to cm neutron scattering angles below 40°. In this region the energy of the recoil protons is too low for detection with a scintillation telescope, so an arrangement for observing the scattered neutrons has been used. The properties of the neutron beam, details of collimation, and the monitoring arrangement were described in reference 1. For the small-angle measurements the diameter of the beam was reduced slightly to $2\frac{1}{2}$ in. at the scatterer, which was at least 4 in.×4 in. in all cases. Extra lead shielding was also added near the scattering table to reduce neutron background.

Two types of scatterers were used, one of liquid hydrogen in a Styrofoam container and the other a pair of polythene and graphite plates which contained equal numbers of carbon atoms. The data taken with the two sets were in agreement, and both are included in the results quoted in Table I.

The apparatus is shown in Fig. 1. A thin (0.48 cm) anticoincidence counter (*A*), 7.6 cm wide by 10 cm high, screened out charged particles from the scatterer region. Following it were a polythene converter, 2.5 ×5.0×7.6 cm, which was centered 64.5 cm from the scatterer and determined the solid angle; a $3\times6\times\frac{1}{2}$ cm stilbene crystal (*B*); 5.08 cm of Cu absorber; a $4\times6\times\frac{1}{2}$

TABLE I. Relative *n-p* cross sections at small angles, normalized to $d\sigma/d\Omega=1.00$ at 40°. Column *B* contains results obtained with a neutron detector; column *D* those measured with a recoil proton telescope.

A Lab angle Θ	*B* Relative $(d\sigma/d\Omega)_{\text{c.m.}}$	*C* C.m. angle θ	*D* Relative $(d\sigma/d\Omega)_{\text{c.m.}}$
5.8	1.12±0.63	12.7	
6.8	1.33±0.14	15	
9.1	0.92±0.11	20	
13.8	0.85±0.17	30	
18.5	1.00±0.07	40	1.00±0.06
23.0	1.05±0.13	50	1.01±0.04
27.8	0.63±0.12	60	0.75±0.02

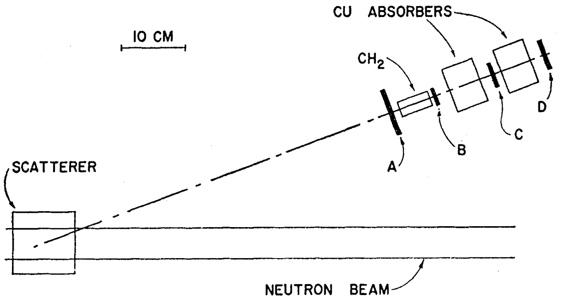

FIG. 1. Plan of neutron beam and detector for small-angle n-p scattering.

cm crystal (C); a second (variable) Cu absorber; and a $5\times10\times\frac{1}{2}$ cm crystal (D). Charged particles produced in the converter were counted by B, C, D in coincidence ($\tau=10^{-8}$ sec). The copper absorber between C and D was adjusted at every angle to the thickness necessary to impose a 365-Mev low-energy cutoff on the primary neutron beam.

At each angle the efficiency of the detector compared with that at 18.5° was computed with the aid of (a) high-energy n-p data,[1–3] (b) the efficiency *vs* proton energy measured for the telescope $B-C-D$ arranged in a sequence similar (but not identical) to that used here. Experimental confirmation of the calculated efficiencies was obtained by comparing the cm scattering from 40°–60° with the previous measurement obtained with a recoil proton telescope. (Column D of Table I).

The results with statistical standard deviations from counting are listed in Table I. Here the observed scattered-neutron counting rates (corrected for detector efficiency) have been transformed into the center-of-mass system and normalized to 1.00 at 40°.

Figure 2 and Table II show all our n-p results, extrapolated to 0° as shown and normalized to a total cross section of 33 mb.[4] The slow angular dependence of the cross section for small θ and its rapid variation near 180° are in qualitative agreement with the cloud-chamber work at 300 Mev,[3] but indicate a change from the symmetry about 90° observed at 90 Mev.[5]

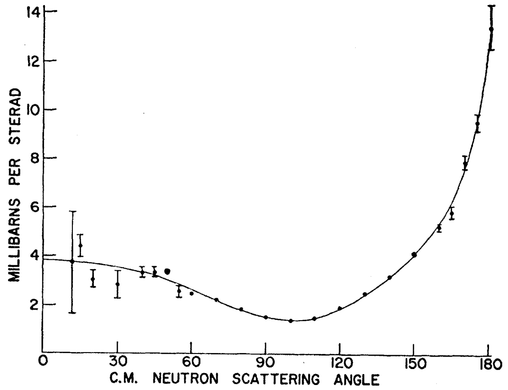

FIG. 2. Differential scattering cross section for 400-Mev neutrons on protons.

TABLE II. Absolute differential n-p scattering cross sections at 400 Mev. Errors are standard deviations computed for all known sources except the uncertainty in the total cross section (33 mb).

C.m. angle θ	$d\sigma/d\Omega$ (mb/sterad)	C.m. angle θ	$d\sigma/d\Omega$ (mb/sterad)
12.7	3.73 ± 2.10	100	1.42 ± 0.06
15	4.43 ± 0.46	110	1.50 ± 0.08
20	3.07 ± 0.37	120	1.94 ± 0.08
30	2.84 ± 0.57	130	2.50 ± 0.09
40	3.33 ± 0.20	140	3.21 ± 0.09
45	3.35 ± 0.20	150	4.17 ± 0.11
50	3.38 ± 0.12	160	5.25 ± 0.14
55	2.56 ± 0.23	165	5.82 ± 0.22
60	2.48 ± 0.08	170	7.93 ± 0.28
70	2.22 ± 0.09	175	9.57 ± 0.34
80	1.85 ± 0.06	180	13.49 ± 0.91
90	1.54 ± 0.06		

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[*] Supported in part by the U. S. Atomic Energy Commission. A more detailed report of this experiment is given in U. S. Atomic Energy Commission Report NYO-6566 (unpublished).

[†] Fulbright Fellow (1953–1954).

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[3] Kelly, Leith, Segrè, and Wiegand, Phys. Rev. **79**, 96 (1950).

[4] V. A. Nedzel, Phys. Rev. **94**, 174 (1954); R. A. Schluter and S. C. Wright, Phys. Rev. **95**, 639 (1954).

[5] O. Chamberlain and J. W. Easley, Phys. Rev. **94**, 208 (1954), have used a similar technique at 90 Mev.

Negative-to-Positive Ratio of Photomesons from Deuterium[*]

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PREVIOUS measurements of the yields of positive and negative pions from the interaction of photons with deuterium indicated that the negative-to-positive ratio is about one for photon energies up to 300 Mev.[1] The ratio has now been measured for mesons of various energies and angles produced by the 500-Mev bremsstrahlung of the Caltech synchrotron.

The magnetic spectrometer used earlier in this laboratory for the detection of positive mesons from hydrogen[2] has been employed in this experiment to select particles of a particular momentum, angle, and sign of charge produced in a high pressure deuterium target by the photon beam. The total angular aperture in the plane of the beam was 20°, and the momentum interval selected was 10 percent of the center value.

For the angles and momenta of this work, most of the particles counted were mesons. Those electrons transmitted by the magnet at low fields were distinguished from mesons by their smaller energy loss in the counters. High-energy electrons were few except at