MEASUREMENT OF THE TRIPLE SCATTERING PARAMETER D_t IN THE FREE n-p SYSTEM*

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The Harvard polarized neutron beam[1] has made possible the first triple scattering experiment on the free neutron-proton system. Figure 1 depicts the apparatus in plan view.

The 128-MeV neutron beam of 42% polarization passes through a precession magnet to a liquid-hydrogen target. The recoiling protons are subsequently analyzed by scattering from carbon through 16°. The experiment therefore measures the transfer of intrinsic angular momentum from one nucleon to another during the interaction. The incident neutron polarization, the normal, $\vec{n}_2$, to the n-p scattering, and the normal, $\vec{n}_3$, to the p-c scattering plane, are parallel or antiparallel to one another, so that we evaluate the parameter D_t where the latter is defined[2] by

$$\langle\vec{\sigma}_t\rangle\cdot\vec{n}_3=\frac{(\vec{n}_2\cdot\vec{n}_3)}{1+P_2(\theta_2)\langle\vec{\sigma}_1\rangle\cdot\vec{n}_2}[P_2(\theta_2)+D_t(\theta_2)\langle\vec{\sigma}_1\rangle\cdot\vec{n}_2],$$

$\langle\vec{\sigma}_t\rangle$ and $\langle\vec{\sigma}_1\rangle$ being the polarizations of the recoil protons and the incident neutrons, respectively.

The simultaneous accumulation of data on D_t in the four channels is possible largely because we are able to reverse the sign of the incident polarization by the magnet,[3] the field of which is at right angles to the beam direction. For example, the number of protons recoiling to the left and then scattered by carbon to the right depends on whether the magnet is off or on. If we define the asymmetries ϵLR, ϵLL, ϵRR, ϵRL by

$$\epsilon LR=\frac{LR(\text{on})-LR(\text{off})}{LR(\text{on})+LR(\text{off})},$$

and so on, then proper combinations lead to

$$P_3P_1D_t=\tfrac{1}{4}\{[(\epsilon RR+\epsilon LR)-(\epsilon LL+\epsilon RL)]+P_2P_3[(\epsilon LL+\epsilon LR)-(\epsilon RR+\epsilon RL)]\}.$$

As an experimental check we also obtain

$$P_1P_2=\tfrac{1}{4}\{[(\epsilon LL+\epsilon LR)-(\epsilon RR+\epsilon RL)]+P_2P_3[(\epsilon RR+\epsilon LR)-(\epsilon LL+\epsilon RL)]\}.$$

The carbon analyzers were calibrated by inserting the analyzer geometry in the Harvard polarized proton beam. The elastic and inelastic contributions to the analyzing efficiency were evaluated by varying the proton energy and the energy threshold systematically. The results agree with published data,[4] so that the angular resolution and recoil energy spectrum characteristic of the D_t geometry could be folded in with confidence. $|P_1|^2$ for the neutron beam was measured by carbon double scattering. Table I summarizes these calibrations and checks.

The D_t measurements are collected in Table II. In Fig. 2 a comparison with several of the Yale semiphenomenological phase-shift solutions is

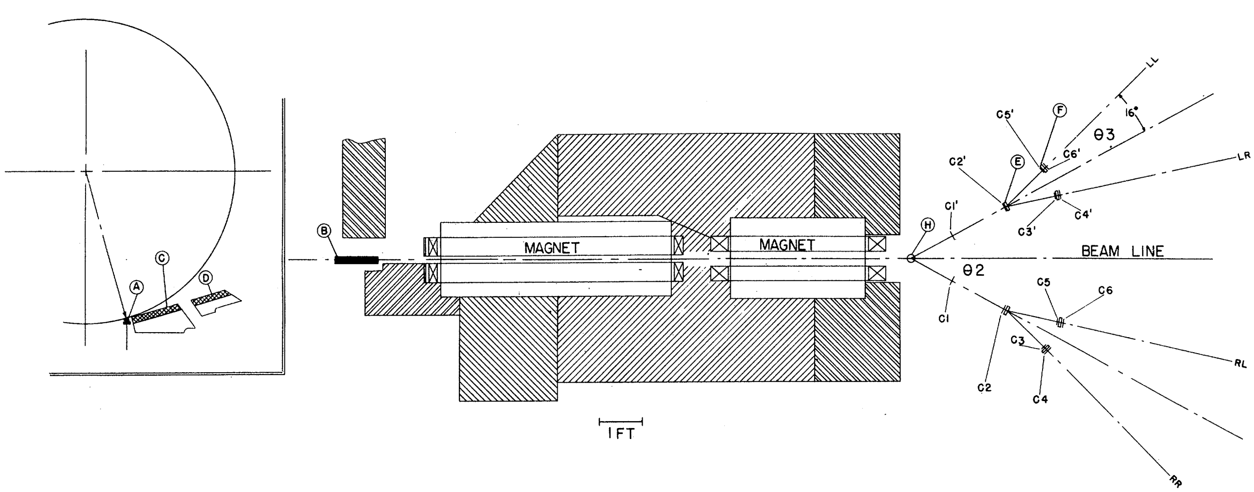

FIG. 1. Top view of the experimental apparatus. (A) Beryllium, (B) carbon polarizer, (C) movable lead shield faced with tungsten, (D) fixed lead shield, (E) carbon analyzers, (F) copper absorbers, (H) hydrogen target.

Table I. Measured polarizing and analyzing efficiencies.

θ_2	P_2P_1	P_2P_3	P_3P_1
160°	+0.022 ± 0.018	+0.016 ± 0.014	+0.132 ± 0.019
150°	-0.004 ± 0.014	-0.003 ± 0.011	+0.120 ± 0.017
142°	-0.021 ± 0.017	-0.014 ± 0.012	+0.115 ± 0.016
133°	-0.047 ± 0.015	-0.027 ± 0.011	+0.104 ± 0.014
124°	-0.020 ± 0.014	-0.010 ± 0.007	+0.085 ± 0.010

Table II. Polarization transfer parameter D_t.

	$E = 128$ MeV
θ_2	D_t
160°	+0.174 ± 0.146
150°	-0.013 ± 0.117
142°	-0.035 ± 0.148
133°	-0.252 ± 0.150
124°	-0.117 ± 0.165

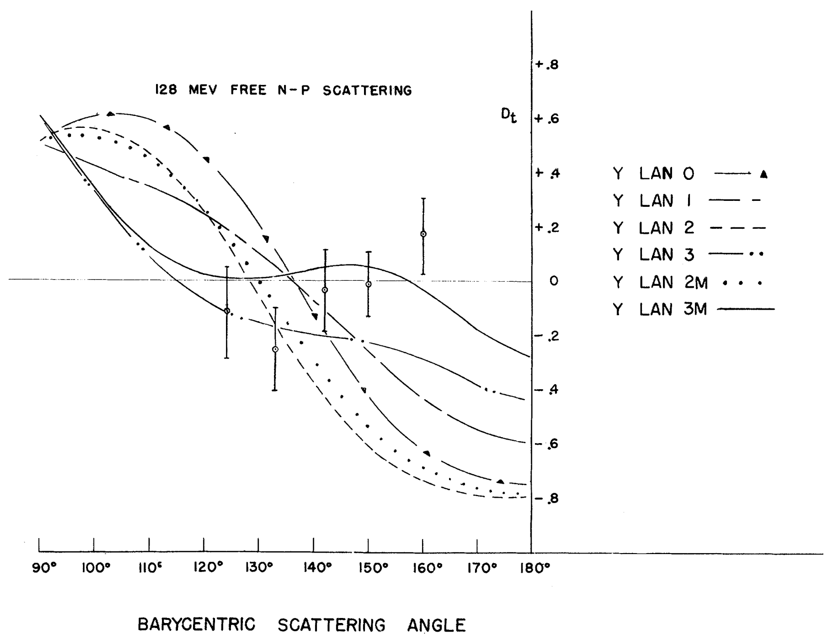

FIG. 2. Experimental value of D_t—comparison with Yale solutions.

made.[5] We note that this transfer parameter discriminates sharply against solutions other than the YLAN3M. The other n-p parameters so far measured have proved rather insensitive[6] to the alternatives. The solution YLAN3M, incidentally, can be represented by a static potential with a boundary condition at the core.[7] Although slight modifications of YLAN3M will no doubt be needed to handle recent data,[8] we conclude that this experiment provides a satisfactory anchor to these variations.

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