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NP TRIPLE SCATTERING EXPERIMENTS AND I=0 NN PHASE SHIFTS

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Abstract: The Wolfenstein parameters D_t, R_t and A_t have been measured in free np elastic scattering with an accuracy of ±0.05 at 220, 325, 425 and 495 MeV in the centre of mass angular range 60° to 160°. The polarisation P has been measured with an accuracy of ±0.015. The I=0 phase shifts differ significantly from theoretical predictions, particularly in the central and spin-orbit combinations of D waves.

The polarised proton beam at TRIUMF is used at an intensity of 100 namp to produce a polarised neutron beam by charge exchange on a 20 cm liquid deuterium target. Monoenergetic neutrons emerging at a lab angle of 9° are selected by time of flight. The intensity of the neutron beam is 10^6/sec over a diameter of 9 cm. The polarisation is given in Table 1, together with values of the R_t parameter for charge exchange from deuterium. Two magnets precess the polarisation to any required orientation.

Proton Energy (MeV)	Neutron Energy (MeV)	Neutron Polarisation (%)	R_t (9° Lab)
237	220	64	-0.81 ± 0.04
343	325	56	-0.75 ± 0.04
443	425	56	-0.78 ± 0.04
578	495	49	-0.69 ± 0.06

Table 1: Neutron polarisation as a function of energy and corresponding values of the R_t parameter for pd → n at 9° lab.

The neutron beam is scattered from a liquid hydrogen target 55 cm long. Scattered neutrons are detected in an array of scintillators 100 x 100 x 30 cm^3 with a positional accuracy of ±3.5 cm horizontally x ± 7.5 cm vertically, and a threshold of 15 MeV. Protons are detected and scattered in a polarimeter consisting of a 53 x 53 x 6 cm^3 block of carbon and an array of 12 multi-wire proportional chambers. This polarimeter has a useful energy range of 110 to 500 MeV and an average analysing power of about 35%.

The relative polarisation P(θ) as a function of angle is determined from the leftright asymmetry using the polarised neutron beam. The absolute normalisation is obtained by comparison with the data of Cheng et al.[1]. The polarisation is also determined absolutely with lower statistical accuracy from the polarisation of the recoil proton using unpolarised incident beam. The two normalisations agree.

The Wolfenstein parameters D_t, R_t and A_t are measured with a precision of ±0.05 at 10° centre of mass steps within the range determined by the kinematic constraints on the neutron counter and polarimeter.

Preliminary values of the I=0 phase shifts are shown in Table 2. This analysis uses our results for P and D_t together with earlier P and $d\sigma/d\Omega$ data. The I=1 phase shifts are taken from our previous analysis[2] of pp data, and g^2 is fixed at 14.25. At 425 and 495 MeV, the χ^2 contribution from earlier data is high, probably indicating systematic errors. A more complete analysis including our R_t and A_t data will be presented at the conference.

Bryan[3] has emphasized that I=0 D waves probe the medium-range forces where one boson exchange (other than π) should dominate. A comparison is made in Fig. 1 of the central, spin-orbit and tensor combinations of D waves with theoretical prediction of Vinh Mau et al.[4]. There is a conspicuous discrepancy in the central and spin-orbit combinations, and a smaller one in the tensor combination.

Lab Energy (MeV)	210	325	425	495
3S1	17.0 ± 1.2	– 2.4 ± 1.1	– 4.3 ± 1.6	(–12.0)
$\bar{\epsilon}$1	5.3 ± 0.5	8.4 ± 0.6	8.0 ± 0.7	11.8 ± 1.7
3D1	–18.6 ± 1.1	–27.4 ± 0.4	–26.0 ± 0.5	–27.8 ± 3.3
1P1	–24.5 ± 2.2	–27.4 ± 0.8	–38.1 ± 2.3	–43.6 ± 1.8
3D2	26.9 ± 2.0	23.9 ± 0.8	24.8 ± 1.1	23.3 ± 1.5
3D3	4.0 ± 0.6	1.9 ± 0.5	5.7 ± 0.7	4.0 ± 1.1
$\bar{\epsilon}$3	6.0 ± 0.4	7.2 ± 0.4	7.3 ± 0.5	8.5 ± 0.9
3G3	– 2.6 ± 0.4	(–4.74)	– 5.1 ± 0.6	(–6.00)
1F3	– 2.9 ± 0.9	– 7.0 ± 0.4	– 4.9 ± 0.4	–10.0 ± 1.3
3G4	5.3 ± 0.9	(–7.90)	8.2 ± 1.0	(11.05)
3G5	0.6 ± 0.4	(–0.45)	– 0.5 ± 0.5	(0.10)
χ^2	66.8	255.2	198.3	282.4
Degrees of Freedom	74	258	106	190

Table 2: I=0 phase shifts from an analysis including our P and D_t data. Values of G waves in parentheses are taken from OPE plus heavy boson exchange contributions calculated by Vinh Mau et al. At 495 MeV, 3S1 is fixed to obtain a stable solution.

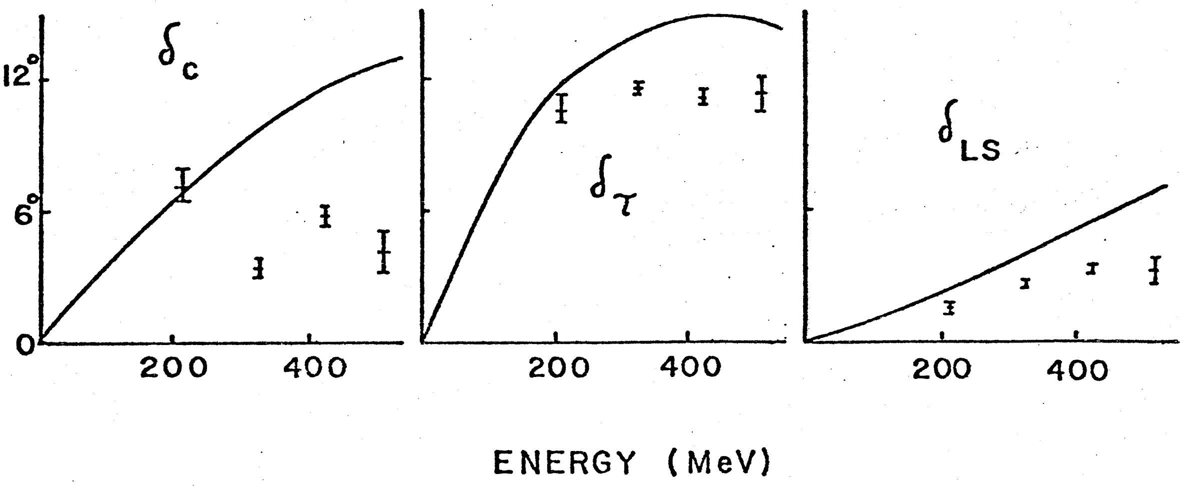

Figure 1: Central, Tensor and spin-orbit combinations of I=0 D Wave phase shifts, compared with the theoretical predictions of Vinh Mau et al.

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