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Measurement of 2nd and 3rd Order Polarization Observables in pd Elastic Scattering*

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We report here on the first measurement of third order polarization observables in proton-deuteron elastic scattering. The observables $C_{NN,OO}$, $C_{ON,NO}$, $C_{NN,NO}$, $C_{SN,SO}$, $C_{SN,LO}$, $C_{LN,SO}$, and $C_{LN,LO}$ have been measured at T_p = 800 MeV in the four-momentum transfer range $0.03 < -t < 0.2$ $(GeV/c)^2$. The experiment is part of an extensive investigation of pd elastic scattering at intermediate energies with the ultimate goal of a complete determination of the scattering amplitudes in spin space.

Beams of 800 MeV protons from the Los Alamos Meson Physics Facility (LAMPF), polarized in three orthogonal directions, were scattered from the KEK frozen-spin target, polarized normal to the scattering plane. The polarization of the scattered protons was measured with the High Resolution Spectrometer (HRS) Focal Plane Polarimeter.[1]

The KEK polarized deuteron target employed a high cooling power horizontal dilution refrigerator.[2] The target cell, 5 cm along the beam, was filled with fully deuterated propanediol beads. In the frozen-spin mode, the target temperature was around 30 mK. We kept the beam intensity below about 10^7 protons/(sec·cm^2) in order to avoid serious depolarization due to beam heating. With a holding field of 1.0 Tesla the spin relaxation time was then about 150 hours. The target polarization, on the average around 25%, was determined by the deuteron spin dependent left-right scattering asymmetry of 800 MeV protons at $\theta_{Lab} = 12.5^o$ where the deuteron analyzing power is known.[3,4] In addition, the deuteron NMR signal has been recorded and will provide a cross-check for the target polarization. Work is in progress on an improved method for extracting the polarization from the NMR signal.

Due to the spin precession in the HRS dipole magnets, the three orthogonal components of the scattered proton polarization could be measured simultaneously. The polarization for peak plus background was measured within a gate in the missing mass spectrum of the scattered protons. Knowledge of the unpolarized peak-to-background yield ratio within this gate allows the deduction of the observables which depend on the target polarization without knowing the polarization of the background. For $\theta_{Lab} > 11^o$, the background (typically a factor of 4 smaller than the elastic peak) was fairly smooth and was mainly due to the excitation of broad natural parity states in ^{12}C and ^{16}O. The peaks due to the ^3He and ^4He in the target are fairly well separated from the deuteron peak. This contribution to the background was determined in a separate measurement with the $^3He/^4He$ coolant removed from the target. On the other hand, at 7^o the deuteron peak is superimposed on a steeply falling background due to elastic and inelastic scattering from states in

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^{12}C and ^{16}O. Further, the deuteron peak was not well separated from the peak due to elastic scattering from ^{3}He. The $^{3}He/^{4}He$ phase boundary in the target was not constant during the experiment, so the yield from ^{3}He and ^{4}He changed from run to run. Quantitative fits of the spectrum allowed us to estimate the contribution of the ^{3}He and ^{4}He peaks to the background.

We are using the notation $C_{ij,kl}$ for our observables. These are defined consistently with a straightforward generalization of the Cartesian formalism given e.g. by Ohlsen.[5] The subscripts i and j (k and l) refer to the incident (outgoing) proton and deuteron spin, respectively. The coordinate systems are chosen in accordance with the 1977 Ann Arbor Convention.[6] The observables were determined from the measured yields and polarizations by a linear least squares calculation, taking into account the spin precession in the target magnet holding field and the small tensor component of the target deuteron polarization.

The results for $C_{NN,00}$ and $C_{SN,S0}$ are shown in Fig. 1. They are compared with a prediction based on non-relativistic multiple scattering theory.[7] The discrepancies are evident, and strongly suggest that a relativistic treatment of the problem may be interesting.

Recently, data have been taken in a similar experiment, with the deuteron target polarized along the beam, providing results for another 8 observables. In principle, it will then be possible for the first time to reconstruct completely the pd scattering amplitudes.[8]

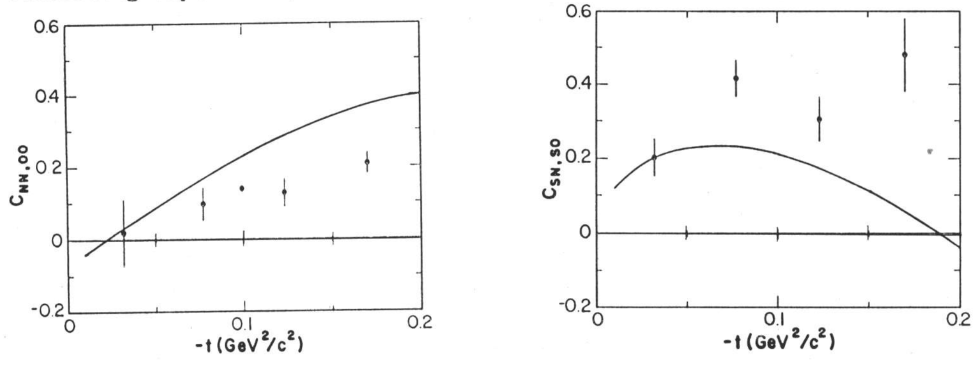

Fig. 1. The observables $C_{NN,00}$ and $C_{SN,S0}$. The curve represents a prediction based on non-relativistic multiple scattering theory.

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