ON POLARIZATION PHENOMENA IN PROTON-DEUTERON
ELASTIC SCATTERING AT MEDIUM AND HIGH ENERGIES

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1. Experimental Status

A series of recent experiments at Argonne National Laboratory has shown that siz­
able polarizations (≈ 30%) exist in the NN system in the medium- and high-energy re­
gion [1]. One may infer that in this energy domain spin effects should also be im­
portant in the three nucleon system. A contour diagram of the analyzing power of deu­
terium for polarized protons in the energy range 10 MeV to 1.5 GeV (Fig. 1) exhibits
a great deal of structure for incident proton energies above 300 MeV [2]. The region
of large positive analyzing powers at backward angles around 550 MeV may be the key
in understanding the observed shoulder in the 180° excitation function and the varia­
tion in slope of the backward angular distributions in Nd elastic scattering [3].

Preliminary results of a complete analyzing power angular distribution at 800 MeV ob­
tained at LAMPF [4] indicate doubly peaked positive values at forward angles already
suggested by the contour diagram shown in Fig. 1. Using a polarized deuteron target
measurements were also made of the asymmetry, between the two states of opposite po­
larization normal to the scattering plane, for the elastic scattering of 593 MeV pro­
tons [5]. The vector polarization and alignment of deuterons with an incident momen­
tum of 3.57 GeV/c (kinetic energy 2.16 GeV) elastically scattered off hydrogen were
measured in a double scattering experiment in the four momentum transfer interval of
0.13 to 0.54 (GeV/c)² [6]. The results of the latter two experiments are shown in Fig. 2.

Fig. 1 Contour diagram of the analyzing power of deuterium for polarized protons.

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2. Theoretical Predictions

At forward angles most theoretical predictions are based upon the Glauber model [7-10]. Earlier calculations which neglected spin predicted an interference minimum in the \( pd \) differential cross section angular distributions not observed experimentally. When the spin dependence of the NN scattering amplitudes was taken into account, an interference minimum was still discernable although it was less pronounced [7]. However, the absence of an interference minimum in the \( nd \) differential cross section angular distributions suggest that the filling of the interference minimum is primarily related to the D-state component of the deuteron. Ignoring the spin dependence of the NN scattering amplitudes, Franco and Glauber calculated [9] the differential cross section angular distributions for the scattering of protons from a polarized deuteron target with the deuteron spins along the direction of the incident beam, along the direction of the momentum transfer vector, and along the direction of their vector product. It was shown that the differential cross sections

\[
N(\phi) = N_0 (1 + A \cos^2 \phi + B \cos \phi)
\]

at an equivalent proton energy of 1.09 GeV. The curves are fits to the data using the Glauber model, Ref. [6].

Fig. 2a Vector analyzing power of hydrogen for polarized deuterons at an equivalent proton energy of 593 MeV, Ref. [5].

Fig. 2b Differential cross section for polarized deuterons at an equivalent proton energy of 1.09 GeV. The curves are fits to the data using the Glauber model, Ref. [6].