Proc. Sixth Int. Symp. Polar. Phenom. in Nucl. Phys., Osaka, 1985
J. Phys. Soc. Jpn. 55 (1986) Suppl. p. 866-867

3.32 Vector Analyzing Powers for the $\vec{n}$+d Breakup Reaction

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Experimental methods to measure the vector analyzing powers $A_y(\theta)$ of several processes in the n-d breakup reaction are being developed at TUNL. These techniques use the pulsed polarized beam facilities at TUNL. Kinematically incomplete and complete measurements of $A_y(\theta)$ for the n-p final state interaction (FSI) have been performed for 12 MeV incident neutrons. As a bonus for measuring the $A_y(\theta)$ of the breakup reaction, high accuracy elastic scattering data were obtained simultaneously.

The incentives for measuring polarization observables in the n-d breakup reaction are multiple. The investigation of the polarization effects in the n-p and n-n FSI should provide information about the relative amounts of singlet and triplet states in the wavefunctions describing these unbound systems. In addition, these data might exhibit some sensitivity to the influence of 3-body forces in these reactions. In the present report we shall concentrate on our measurements of $A_y(\theta)$ for the n-p FSI. The n-p pair will be denoted as d^*, since it resembles a deuteron with zero binding energy. However, because it is an unbound system, its spin and parity are not well defined, unlike the case for the deuteron. Prior to the present measurements, the only $A_y(\theta)$ data for n-d breakup were those of Fischer et al.[1] at 14.3 and 29.6 MeV and that of Klages et al.[2] above 22 MeV.

The experimental setup for the present measurements is shown in Fig. 1. Two pairs of shielded NE213 scintillators were used to detect the scattered neutrons. This allowed the simultaneous measurement of $A_y(\theta)$ at two angles. A pair of unshielded detectors were placed at forward angles to obtain kinematically complete data for one angle pair. The polarized neutrons were produced via the $^2H(\vec{d},\vec{n})$ source reaction, using the neutrons emerging at 0°. The incident deuteron beam was pulsed to enable the use of time-of-flight (TOF) techniques to discriminate against the breakup neutrons from the source reaction. The center scatterer was a NE232 deuterated scintillator and thus provided energy information about the recoil particles. The energy of the scattered neutrons was determined by measuring the TOF from the center scatterer to any of the side detectors.

For the kinematically incomplete measurements a valid event consisted of a double coincidence between an event in the center detector and an event in any one of the shielded detectors. A valid event for the kinematically complete measurements was constituted by the triple coincidence CD·L1·R3 or CD·L1·L3. All valid events were constrained by the requirement that the events were caused by ground state neutrons from the source reaction.

The present elastic data are combined with the data of Tornow et al.[3] to form a high accuracy set of n-d elastic scattering data at 12 MeV. Figure 2 is a comparison of this n-d data set to the charge-symmetric p-d data. The curves through the data are derived from Legendre polynomial fits the product of $A_y(\theta)$ and $\sigma(\theta)$. The differences in the p-d and n-d data are consistent with our findings[4] at 10 and 14 MeV. Figure 3 is a plot of the $A_y(\theta)$ data for the d^* with relative n-p energy less than 1 MeV in comparison to the n-d elastic data. The trend of these data suggest that the $A_y(\theta)$ for the d^* follows the shape of the elastic data. This implies that $A_y(\theta)$ for the singlet state is approximately equal to that of the triplet state. To confirm the shape of $A_y(\theta)$ for the d^*, higher accuracy data will be obtained in the angular region where $A_y(\theta)$ for elastic scattering is a maximum.

This work supported by the USDOE, Contract No. DE-AC05-76ER01067, the U.S. National Science Foundation under PL-480, and the Deutsche Forschungsgemeinschaft.

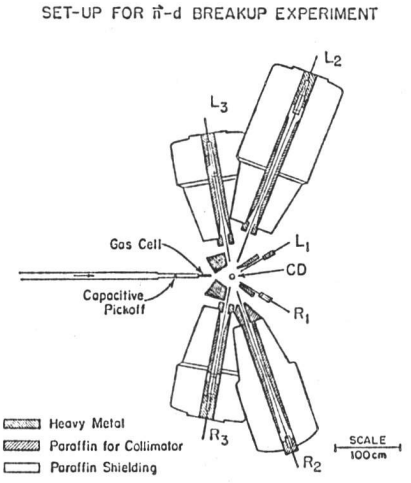

Fig. 1. Experimental setup for $\vec{n}$+d breakup measurement.

Detector Sizes
L1, R1: 2.5 x 5.1 x 5.1 cm
L2, R2: 12.7 x 5.1 cm, 8.9 x 5.1 cm
L3, R3: 5.1 x 15.2 x 7.6 cm
CD: 2.5 x 3.8 cm

Flight Paths
L1, R1: 50 cm
L2, R2: 260 cm
L3, R3: 150 cm
Gas cell to DC: 38 cm

^{2}H Gas Cell
Press. = 100 psig
Length = 3 cm

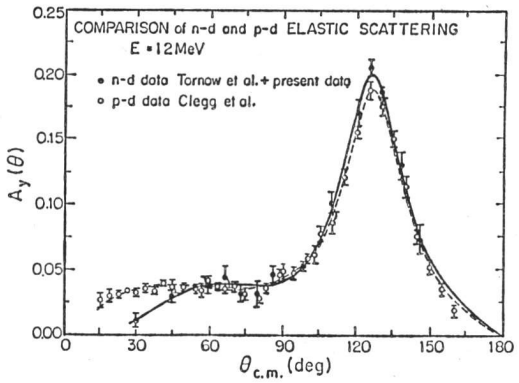

Fig. 2. Plot of $A_y(\theta)$ for n-d and p-d elastic scattering at 12 MeV.

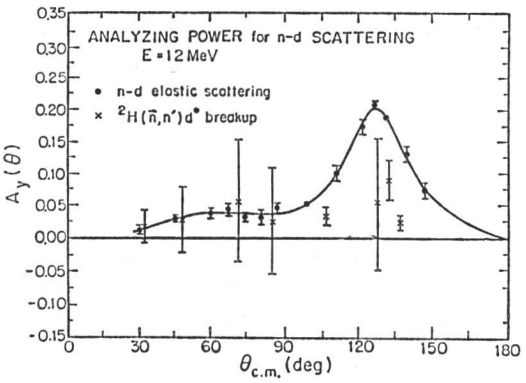

Fig. 3. Comparison of $A_y(\theta)$ for the n-p FSI to n-d elastic scattering at 12 MeV.

References

1) R. Fischer et al., Lecture Notes in Physics 82, "Few Body Systems and Nuclear Forces I", ed. H. Zingl et al., (New York: Springer-Verlag, 1978) 259.
2) H.O. Klages et al., Neutron-Nucleus Collisions: A Probe of Nuclear Structure, AIP Conf. Proc. No. 124, ed. J. Rapport et al., (New York: AIP, 1985) 137.
3) W. Tornow et al., Nucl. Phys. A296 (1978) 23.
4) W. Torrow et al., Phys. Rev. Lett. 49 (1982) 312; W. Tornow et al., Phys. Rev. C 27 (1983) 2439.