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3.4 Large-Angle Neutron-Proton Analyzing Power Data at 16.9 MeV

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High-precision n-p analyzing power measurements performed at TUNL[1] at 16.9 MeV and at Wisconsin[2] at 25 MeV indicate considerable discrepancies between data and phase-shift predictions at neutron center-of-mass scattering angles larger than about 125°, while the somewhat less accurate data from Karlsruhe[3] at 25 MeV seem to be in better agreement with phase shifts. Unfortunately, the Karlsruhe data at 17 MeV are about a factor of 5 less accurate than the TUNL data, therefore, no conclusions can be drawn at this low energy.

It is well known that precise n-p analyzing power data are difficult to obtain at backward scattering angles $\Theta_{c.m.} > 120°$ due to the experimental problems involved in the detection of the scattered neutrons. Instead of detecting the backward scattered neutrons, more reliable results can be obtained by recording the corresponding protons, recoiling forward out of a thin radiator[4,3]. However, the accuracy of this methods is limited for neutron energies above about 18 MeV by background problems, due to neutron induced reactions on carbon, which is part of the radiator.

In view of the importance of large-angle n-p analyzing power data on nucleon-nucleon phase-shift analyses and of the experimental problems involved at higher energies, we decided to take backward-angle n-p analyzing power data at 16.9 MeV in order to complete the very accurate angular distribution from TUNL towards neutron scattering angles up to 166° c.m.

The experimental arrangement is shown in Fig. 1. The reaction $^3H(d,n)^4He$ at a mean deuteron energy of 3.3 MeV and a reaction angle of $\Theta = 69°$(lab) served as a source of polarized neutrons. A tritiated titanium target was bombarded with up to 80 µA of deuterons which were accelerated by the Tübingen Van de Graaff. The neutron beam had an energy of (16.9 ± 0.2) MeV and a polarization of $p_y = -0.315 \pm 0.015$. This beam passed through a collimator which was inserted in a superconducting spin precession solenoid. At a distance of 120 cm from the neutron source a scintillating radiator was mounted in a thin-walled scattering chamber. The radiator, 2 mm thick with an active area of 15 x 35 mm², was viewed by two phototubes. Recoil protons were detected using four silicon solid state side detectors (1000 µm thick x 13.8 mm diameter), located symmetrically with respect to the incident neutron beam axis at ±7° and ±17° or ±12° and ±22° at a distance of 15 cm from the radiator. The fast output signals of the detectors were fed into fast amplifiers and discriminators which created the timing signals in order to start four time-to-amplitude converters. The stop signal was derived from the coincidence signal between the two phototubes.

Figure 2 shows a typical proton time-of-flight spectrum which is almost free of any background events. Time increases from right to left.

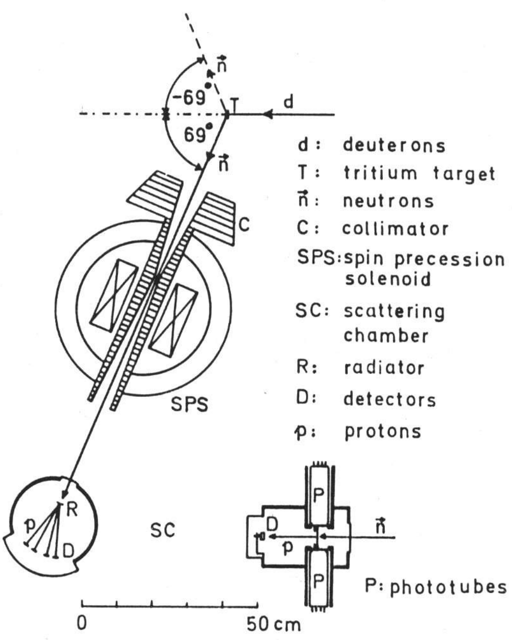

Fig. 1. Experimental arrangement

The counts on the left side of the proton peak are mainly due to recoil protons, which were produced by drive-in neutrons from the reaction $^2H(d,n)^3He$. Due to the large Q-value difference between $^3H(d,n)^4He$ and $^2H(d,n)^3He$, contributions from the $^2H(d,n)^3He$ reaction can easily be separated from the time-of-flight peak of interest. This fact was investigated in a separate run with the tritiated target replaced by a deuterated target. Due to the high threshold for neutron induced reactions on carbon, the region beneath the proton peak is free of any contributions from (n, charged-particle)-reactions which take place in the radiator.

Instrumental asymmetries were compensated applying two different procedures or a combination of both: 1) A superconducting solenoid was used to precess the neutron spin through 180° either clockwise or counterclockwise, allowing the roles of the side detectors to be interchanged. 2) The whole experimental setup, scattering chamber and spin precession solenoid, was rotated to the other side of the incident deuteron beam direction ($\Theta = \pm 69°$ lab).

Our results obtained till now are shown in Fig. 3 by triangles in comparison to the data from TUNL (dots) and from Morris et al.[5] (squares) at the same incident neutron energy. Our data follow the trend of the previous data, which were obtained via neutron detection. The statistical uncertainty of our present data (±0.004-0.005), which is still about a factor of two larger than the uncertainty of the TUNL data, is limited mostly by the low polarization of our neutron beam. We hope to continue our experiment using the $^2H(\vec{d},\vec{n})^3He$ polarization transfer reaction at a Tandem accelerator laboratory.

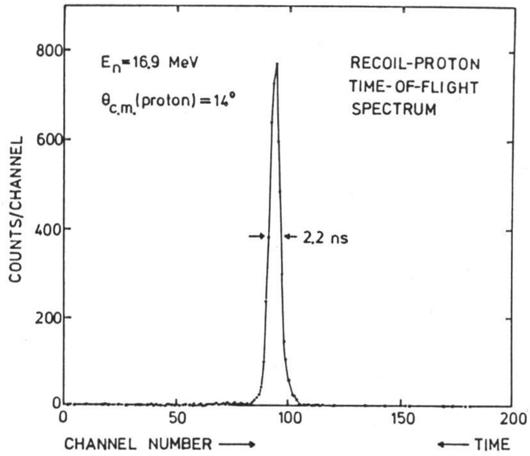

Fig. 2. Proton time-of-flight spectrum

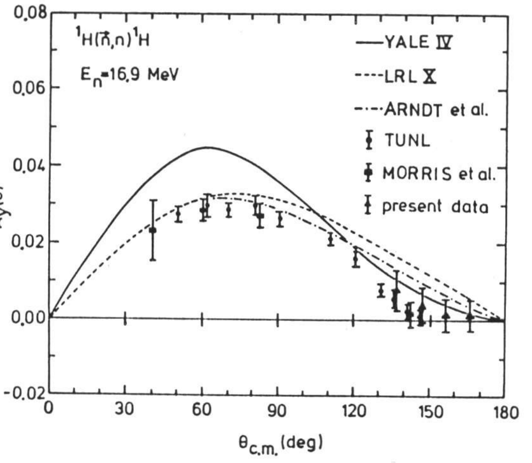

Fig. 3. Present analyzing power data in comparison to previous results and phase shift predictions[6]

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