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3.5 Analyzing Power in Large-Angle Neutron-Proton Scattering at 25 MeV

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A renewed interest in the nucleon-nucleon interaction at low energies has recently caused several groups to undertake high precision scattering experiments in the p-p and n-p systems [1-4]. The results of accurate n-p analyzing power measurements [2,3] are poorly described by energy dependent phase shift analyses and current phenomenological nucleon-nucleon potentials. The biggest discrepancies between experiments and theory occur at large backward angles [2,3,5], where the data tend to favor zero-crossing solutions, which demand the inclusion of F-waves [2]. In order to investigate this problem, we performed a new measurement of the n-p analyzing power for angles between 130° and 165°. Since for large-angle scattering the method previously used [3] was difficult because of the low energy of the scattered neutrons, the new measurements made use of a counter telescope for the recoil protons. The telescope consisted of a thin hydrocarbon scintillator (center detector), which acted as a radiator, in coincidence with two side detectors 50 cm from the radiator, placed symmetrically to the left and right of the beam axis.

Polarized 25 MeV neutrons were produced using the polarization transfer in the $T(\vec{d},\vec{n})^4He$ reaction by bombardment of a 0.85 atm. tritium gas target with an approx. 0.5 μA vector polarized deuteron beam. The deuteron polarization ($p_y \approx 0.61$) was reversed every 0.25 sec by switching RF transitions at the colliding beam polarized-ion source [6]. The deuteron polarization was continuously monitored by using a thin carbon foil transmission polarimeter placed after the analyzing magnet of the tandem accelerator. Neutrons emitted at 0° impinged on a 3 mm thick radiator. Each of the side detectors was 6 mm thick and had an angular spread of 3° (rms angle) in the laboratory frame. For each coincident event between the center and one of the side detectors the pulse height in each detector and the neutron time of flight were recorded. Examples of the spectra are shown in fig. 1.

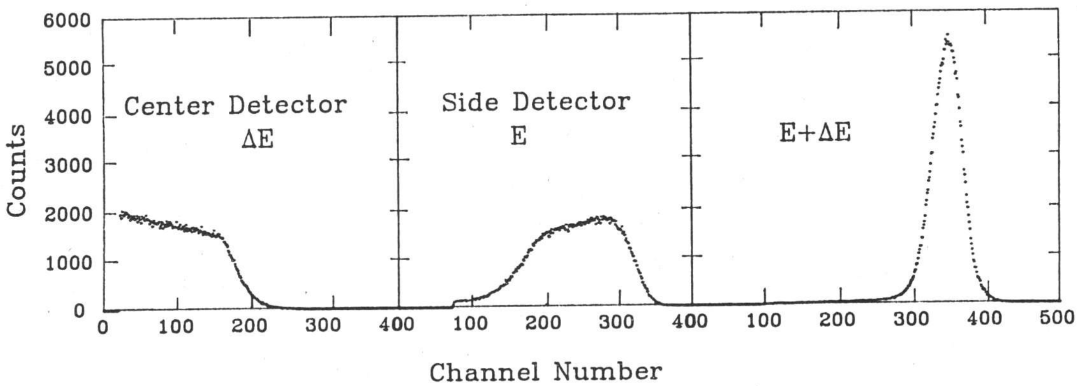

Fig.1. Experimental spectra at a laboratory angle of 15°.

Special precautions were taken and additional measurements were done in order to avoid systematic errors. For example, an erroneus assymmetry could be caused by neutrons scattered in the scintillator target and detected in the side detectors. This was shown to be negligible in a separate measurement using a steel plate placed in front of the detectors to stop the recoil protons. Also, the effect of the disturbing $^{14}N(\vec{d},\vec{p})$ reaction was diminished by placing a ^4He balloon between the neutron source and the center detector. Iron shadow bars were used to shield the side detectors from the direct neutron flux produced in the tritium cell. The background from accidental coincidences, which contributed only 0.1% of the n-p scattering events, was subtracted in the off-line data analysis. Finite geometrical dimensions of the detection system were taken into account by calculating the angular acceptance function and effective neutron polarization. The overall normalization of the data was determined to 2.5% by measuring the polarization transfer coefficient for the $T(\vec{d},\vec{n})^4He$ reaction in a separate experiment ($K_y^{y'}(0°) = 0.512$, see contribution to this conference).

The final results are shown in fig.2 together with other back angle data [3,4] and theoretical curves from the global phase shift analyses[7] and potential model of the N-N interaction[8].

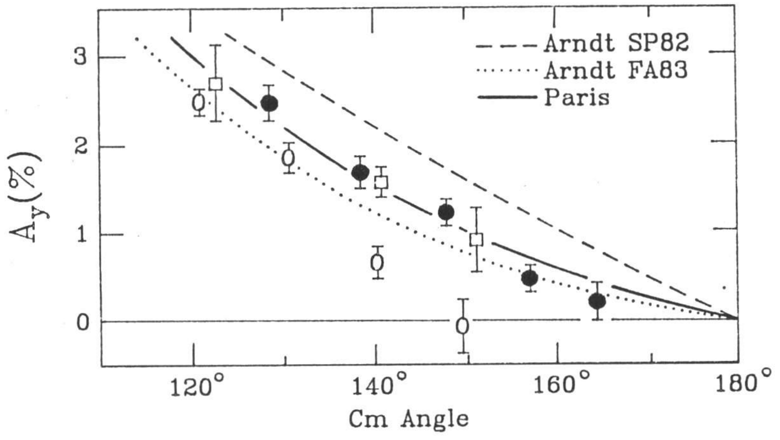

Fig.2. Precise large-angle data (filled circles: present work; open circles: ref. 3; squares: ref. 4) and theoretical predictions[7,8].

The new measurements extending to large scattering angles agree very well with the most recent Paris potential prediction. They rule out completely a zero-crossing of the n-p analyzing power at $\theta_{cm} \approx 150°$. For large-angle scattering we consider the method used here more reliable than the conventional method [2,3] in which the scattered neutrons are detected, since background is negligible and the good events are clearly identified by the well resolved $E + \Delta E$ spectrum.

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