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SLAC EXPERIMENT E142*

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Deep inelastic scattering experiments to measure the proton spin-dependent structure function were first pioneered in SLAC experiments in the 1970's [1]. These early experiments established the existence of large asymmetries in the spin structure of the proton predicted by the parton model. Despite the success, the results did not appear to be revealing new fundamental insights into the models. The experiments were, moreover, difficult, and SLAC's interest in constructing a linear collider to study the Z_0 boson ended the program to study in more detail the nucleon spin-dependent structure functions.

In 1988, the EMC collaboration published results [2] on a measurement of the proton spin-dependent structure function with data extending down to low values of x. The EMC results gave a more accurate determination of the integral over x of the proton spin-structure function, $\int g_1^p(x)\,dx$, and the result seems to violate a Quark Parton Model sum rule derived by Ellis and Jaffe [3]. An interest in the field was quickly reestablished and over two hundred theoretical papers have been generated.

In May of this year, SLAC reopened the study of this field of physics by approving experiment E142—an experiment to measure the neutron spin-dependent structure function. In this report, I describe the goals of experiment E142 and how we hope to achieve them.

The goal of experiment E142 is to measure the neutron spin-dependent structure function over a range in x from 0.04 to 0.6 with $Q^2 > 1$ GeV^2. The measurement would provide the first complete test of the Bjorken polarization sum rule [4] by establishing the value of $\int g_1^n(x)\,dx$. The E142 experiment consists of scattering a high-energy, longitudinally polarized electron beam off a longitudinally polarized ^{3}He gas target and detecting the scattered electons in a two-arm spectrometer at 4.5° and 7°. The experiment will measure the asymmetry

$$A_1 = \frac{(\sigma^{\uparrow\downarrow} - \sigma^{\uparrow\uparrow})}{(\sigma^{\uparrow\downarrow} + \sigma^{\uparrow\uparrow})} \tag{1}$$

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as a function of x and Q^2 where $\sigma^{\uparrow\downarrow}$ and $\sigma^{\uparrow\uparrow}$ correspond to the scattering cross-sections for beam and target polarizations anti-parallel and parallel, respectively. From the asymmetry measurements, one extracts the spin-dependent structure function, $g_1^n(x)$.

The electron beam for this experiment will be similar to the polarized beam used for the measurement of parity violation in polarized electron deuteron scattering [5]. The beam will run at an energy of 22.66 GeV and should deliver an average current of 10 μA on the target, with a polarization of 40 $\pm$ 2 % (syst). Polarized electrons are produced by a GaAs source presently being built for the SLC. Reversal of the electron beam polarization will be done randomly on a pulse-to-pulse basis, and measurements of the beam polarization will be done intermittently with a set of Moller polarimeters. A short run of the beam at an energy of 25.75 GeV is being considered in order to measure the structure function at lower x.

The E142 target uses polarized ^{3}He gas. A polarized ^{3}He nucleus represents a fairly good approximation to a polarized neutron target. To the extent that the nucleus is in a $^1S_0$ ground state, the two proton spins align themselves anti-parallel to one another, due to the Pauli exclusion principle. Hence, scattering off a polarized ^{3}He nucleus is essentially equivalent to scattering off a polarized neutron plus two unpolarized protons. The theoretical uncertainty in extracting the neutron spin-dependent structure function from ^{3}He is expected to be small [6].

The target consists of a 30 cm long glass tube filled with ten atmospheres of ^{3}He gas. The ^{3}He nuclei are polarized via spin exchange collisions with polarized Rb atoms. The Rb atoms (present at a pressure of $\sim$ .014 torr) are polarized via optical pumping by circularly polarized light from titanium-sapphire lasers. ^{3}He polarizations of 50 $\pm$ 2.5% (syst) should be obtained for these targets in the presence of the SLAC electron beam. Test runs of similar 3.5 atmosphere targets at BATES have already been done successfully. Eight to ten atmosphere targets have been built at this time, though none of these higher pressure targets have been used in electron test beams. Measurements of the target polarization will be done using standard NMR techniques, and target polarization reversals can be achieved in a few seconds.

The E142 spectrometer consists of two arms, each with a solid angle acceptance of 0.5 msr and a momentum acceptance covering a range from 6 GeV/c to 18 GeV/c. Events of differing momenta will be collected simultaneously and their resolution determined to $\Delta p/p \approx 3\%$. With the acceptance and luminosity proposed, we expect to acquire about two electron events per pulse in the 7° arm. Collecting 90 hours of data on tape per arm with the polarizations given above will allow a measurement of $A_1(x)$ to an accuracy shown in Figure 1. The projected statistical errors in the range of measurement are substantially smaller than the published proton results.

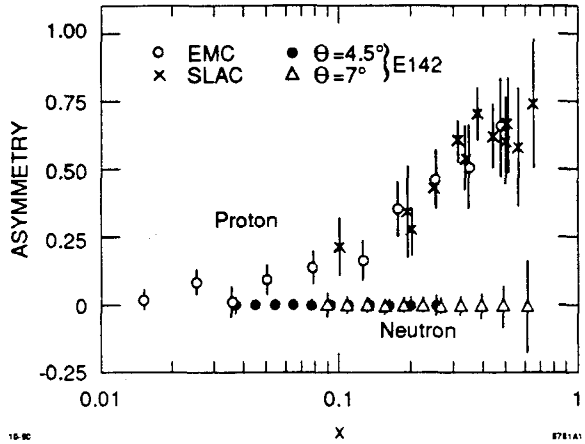

Figure 1 Proton spin dependent structure functions and expected error bars on the neutron measurement from E142.

Systematic uncertainties should be similar to the past experiments, and dominated by the uncertainty in the polarization measurements. On a point-to-point basis, the statistical uncertainties in the asymmetry will likely dominate over the systematic uncertainties, since the systematic uncertainties scale with the size of the asymmetry.

In addition to the plan for measuring $A_1(x)$, we also intend to measure $A_2(x)$. The ability to polarize the ^{3}He target transverse to the electron beam direction is being incorporated into the present target design.

In summary, the E142 experiment should be able to provide the missing piece in testing the Bjorken sum rule to about ±15%, and the shape of the asymmetries for the neutron should give valuable information for untangling the mystery of the Ellis-Jaffe sum rule violation.

A successful run of experiment E142 will likely open up the possibility for further experiments at SLAC using polarized deuterium and proton targets and higher energy (i.e., 50 GeV) polarized electron beams.

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