The Generalized GDH sum rule

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We have made a precise measurement of the spin dependent $^3\vec{\mathrm{He}}(\vec{\mathrm{e}}, \mathrm{e}')$ inclusive cross sections and asymmetries to evaluate the generalized Gerasimov–Drell–Hearn (GDH) integral at low Q^2 from 0.02 to 0.3 GeV^2 (Chen *et al.* 1997). The GDH sum rule relates the helicity dependent photoproduction cross sections for scattering a circularly polarized photon beam off a longitudinally polarized target. For spin 1/2 targets,

$$\int_{\nu_{\mathrm{th}}}^{\infty} [\sigma_{\frac{1}{2}}(\nu) - \sigma_{\frac{3}{2}}(\nu)] \frac{\mathrm{d}\nu}{\nu} = -\frac{2\pi^2 \alpha \kappa^2}{\mathrm{M}^2} \quad (1)$$

where κ, M are the anomalous magnetic moment and mass of the target, ν_{th} the inelastic threshold, ν the photon energy, and $\frac{1}{2}$ ($\frac{3}{2}$) corresponds to the case of the photon helicity being parallel (anti-parallel) to the target spin.

The GDH integral can be generalized to finite Q^2. One method is to replace the photoproduction cross sections with the electroproduction cross sections (see eq. 2).

$$\mathrm{I}(\mathrm{Q}^2) = \int_{\nu_0}^{\infty} [\sigma_{\frac{1}{2}}(\nu, \mathrm{Q}^2) - \sigma_{\frac{3}{2}}(\nu, \mathrm{Q}^2)] \frac{\mathrm{d}\nu}{\nu} \quad (2)$$

Other generalizations exist that include a flux factor or can be extended in terms of the g_1 spin dependent structure function. All these generalizations reduce to the original GDH sum rule at $\mathrm{Q}^2 = 0$. Due to its connection with the Bjorken sum rule, the extension of the integral to finite Q^2 provides a bridge from the non-perturbative region to the perturbative region of QCD. This bridge allows a comparison of the measured quantity to theoretical predictions over the entire Q^2 range.

Experiment E97-110 was conducted at the Thomas Jefferson National Accelerator Facility (JLab) in Hall A. Up to 10 μA of the longitudinally polarized electron beam was utilized at several incident energies from 1.15 to 4.4 GeV. The beam polarization was measured with both Møller and Compton polarimeters, and the average polarization was $\sim$ 75%.

During the experiment, we used one of the Hall A high resolution spectrometers along with a septum magnet to detect the electrons at scattering angles of 6° and 9°. The septum magnet was necessary to reach the small angles, since the minimum spectrometer angle is 12.5°. The spectrometer detector package contains drift chambers for particle tracking, scintillators for triggering the data acquisition, and preshower, shower and Cherenkov detectors for particle identification. Using these detectors, the pion contamination was reduced by a factor of 10^4.

A polarized ^{3}He target with 40% average polarization in beam and 10^{36} $(\mathrm{cm}^2{\cdot}\mathrm{s})^{-1}$ luminosity was used as an effective polarized neutron target. Data were acquired with both longitudinal and transverse target polarization configurations. The target polarization was measured by two methods of polarimetry: NMR and EPR.

The new low Q^2 measurements of the extended GDH integral allow us to test the dynamics of Chiral Perturbation Theory, to learn about the spin structure of ^{3}He and the neutron, and to determine if the slope of the integral changes sign, which would allow an extrapolation to the real photon point. Our data complements the data from the previous Hall A experiment E94-010 below Q^2 = 0.1 GeV^2. Fig. 1 shows the expected quality of the results for the neutron extended GDH integral. Currently the data analysis is underway: The false asymmetries are consistent with zero, preliminary elastic asymmetries are in good agreement with the world data, and understanding of the spectrometer optics is close to completion.

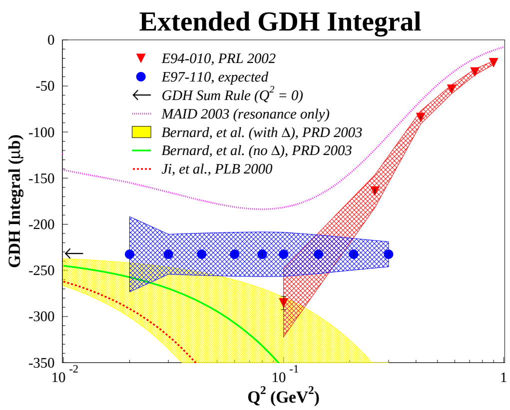

Figure 1. *E97-110 expected results along with the results from the previous experiment, E94-010. Also the MAID phenomenological model and two Chiral Perturbation Theory calculations are shown.*

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References

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