Nucleon Resonances Spin Structure – *RSS*: Experiment 01-006 at Jefferson Lab

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Abstract.
We have measured the spin structure of the nucleon in the region of the resonances (final state mass $W <\sim 2$ GeV) at intermediate four-momentum transfer $Q^2 \sim 1.3$ (GeV/c)^2. Double-spin inclusive asymmetries for longitudinally polarized 5.75 GeV electrons incident on longitudinal and transverse solid polarized targets were measured in Jefferson Lab's Hall C. Frozen ammonia and deuterated ammonia were used as the polarized materials. The neutron spin structure is extracted from the proton and deuteron asymmetries. We present new results for the proton measured asymmetries $A_{\|}$ and $A_{\perp}$ and spin structure functions g_1 and g_2, and preliminary results for the deuteron asymmetries. These are the first measurements of the transverse proton and deuteron spin structure in the resonances. We also report on our measurement of the ratio of the proton electromagnetic form factors with our polarized target.

The spin structure functions (SSF's) g_1 and g_2, and their related spin asymmetries A_1 and A_2, require the measurement of two asymmetries for different relative orientations of the target spin and the lepton beam helicity. The usual approach is to measure the asymmetries with the nucleon spin parallel ($A_{\|}$) and perpendicular ($A_{\perp}$) to the beam helicity. There is a significant lack of $A_{\perp}$ measurements for much of the Q^2-x kinematic plane for $x >\sim 0.5$, in particular for Q^2 below ~ 6 [GeV/c]^2. Much of the $x > 0.5$ region for Q^2 up to ~ 10 [GeV/c]^2 corresponds to $W \leq 2$ GeV, which is dominated by the nucleon resonances. Experiment 01-006 (*RSS*) [1] at Jefferson Lab's Hall C, concentrated on a precision measurement of proton and deuteron A_1 and A_2 in the resonances. The main goals of this experiment are to study the W dependence of the SSF's, look for the onset of polarized local duality, and explore the contribution of twist-3 processes to g_2.

The asymmetries were measured by scattering 5.76 GeV polarized electrons accelerated with CEBAF on polarized frozen ammonia (NH_3) and deuterated ammonia (ND_3) targets. The scattered electrons were detected in the High Momentum Spectrometer-HMS parked at 13.15°. Two settings of the HMS central momentum were used, 4.73 and 4.09 GeV/c. The kinematic range covered with these parameters extends from 0.6 GeV to 2 GeV in W at $Q^2 \approx 1.3 \pm 0.3$. The measured asymmetries are obtained from the ratio of the difference over the sum of charge normalized event counts for opposite

[1] U. Basel, Florida International U., Hampton U., U. Massachusetts, U. Maryland, Mississippi S. U., North Carolina A&T U., U. of N. C. at Wilmington, Norfolk State U., Old Dominion U., S. U. New Orleans, U. of Tel-Aviv, TJNAF, U. of Virginia, Virginia P. I. & S. U., Yerevan Physics I. Spokespersons: O. A. Rondon (Virginia) and M. Jones (TJNAF).

beam helicities, N_L, N_R. This ratio is normalized by the beam polarization P_b, target polarization P_t and dilution f of the polarized nuclei by unpolarized nucleons in the target (nitrogen, liquid He, etc.)

$$A_{\parallel,\perp} = \frac{1}{f_{RC}}\left(\frac{1}{C_N f P_b P_t}\frac{N_L - N_R}{N_L + N_R} + C_D\right) + A_{RC}. \tag{1}$$

f_{RC}, A_{RC} represent radiative corrections and C_N, C_D correct for the small N polarization .

The beam current was limited by the polarized target to around 100 nA. The beam was rastered over a 2 cm diameter circle to spread the induced radiation damage. The beam polarization was measured with the Hall's Møller spectrometer. For the perpendicular asymmetry the polarization was (66±0.5)% and (71±0.5)% for the parallel data. The polarized target operated at 5 T and 1 K. Dynamic nuclear polarization of the ammonia by microwave irradiation produced in-beam proton polarizations of 70% and deuteron polarizations of 20%. The polarization was measured continuously during the experiment by the NMR technique. The asymmetry from elastic $e-p$ scattering was measured simultaneously. The parallel elastic asymmetry is very insensitive to the proton form factor ratio G_E/G_M and was used to determine the product P_bP_t with better precision than with NMR and Møller polarimetry. The perpendicular one is very sensitive to the ratio, and it was used to determine $\mu G_E/G_M = 0.89 \pm 0.025$.

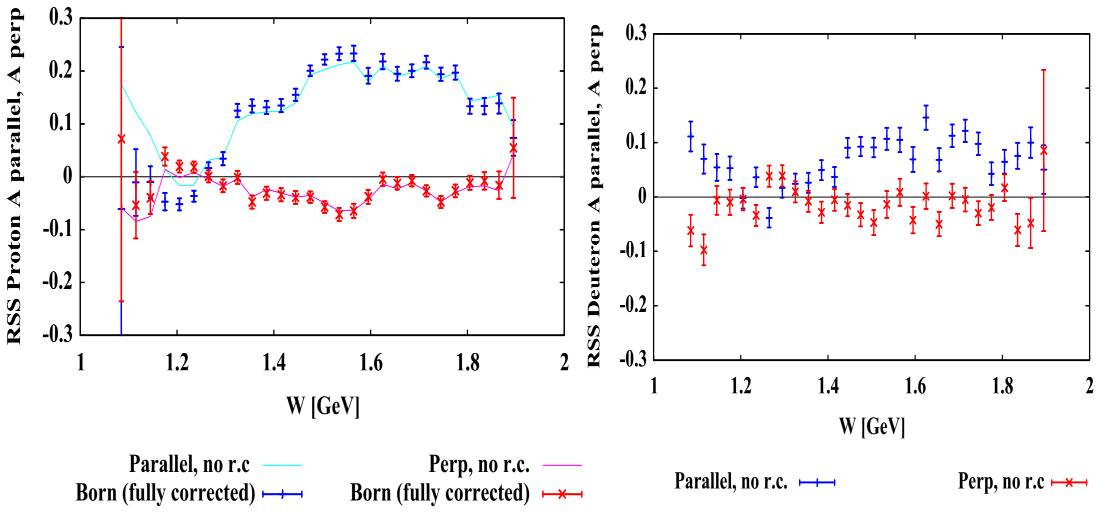

FIGURE 1. $A_{\parallel}$ and $A_{\perp}$ (r.c.=radiative corrections) for protons (left) and deuterons (no r.c.) (right).

The dilution of the asymmetries by the unpolarized nucleons is calculated using a Montecarlo simulation. Model nuclear cross sections [1] were combined with parameterizations [2, 3] of single-arm proton and deuteron resonance data measured in Hall C. The packing fraction by volume of ammonia in the target cells (ranging from ~ 0.52 to ~ 0.61) was determined by comparing data to Montecarlo rates for ammonia, calibrated using rates from C disks of known thickness. $A_{\perp}$ and $A_{\parallel}$ for protons and deuterons are shown on the left and right panels of Figure 1. The proton results are nearly final, while radiative corrections have yet to be applied to the deuteron. A_1 and A_2 are related to $A_{\parallel}$

and $A_\perp$ by

$$
\begin{aligned}
A_1 &= \frac{1}{(E+E')D'}\left((E-E'\cos\theta)A_\parallel - \frac{E'\sin\theta}{\cos\phi}A_\perp\right) \\
A_2 &= \frac{\sqrt{Q^2}}{2ED'}\left(A_\parallel + \frac{E-E'\cos\theta}{E'\sin\theta\cos\phi}A_\perp\right), \quad D' = \frac{1-\varepsilon}{1+\varepsilon R}
\end{aligned}
\tag{2}
$$

where $\varepsilon = (1+2(1+\gamma^2)\tan^2(\theta/2))^{-1}$. The unpolarized proton structure functions F_1 and R used to obtain $g_1 = F_1/(1+\gamma^2)(A_1+\gamma A_2)$ and $g_2 = F_1/(1+\gamma^2)(A_2/\gamma - A_1)$ (with $\gamma^2 = 4x^2M^2/Q^2$) are from fits to $e-p$ resonance data [2, 4]. Proton g_1 and g_2 are shown on the left panel of Figure 2. The difference between the measured g_2 and its twist-2 component g_2^{WW} indicates the presence of higher twist. The right panel shows our results compared with g_1 computed from PDF's evolved to our kinematics. Integrals of $g_1$in the resonances can be compared to the corresponding ones from PDFs to test for the polarized counterpart of local (Bloom-Gilman) duality observed in F_2^p [8].

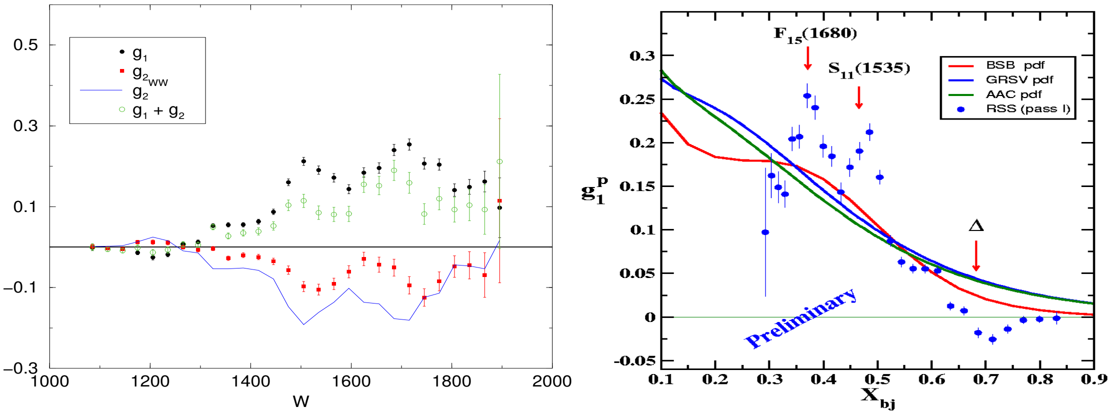

FIGURE 2. g_1^p and g_2^p (left). Our results along with g_1 from PDF's BSB [5],GRSV [6],AAC [7](right).

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