THE RESONANCE SPIN STRUCTURE MEASUREMENT AT HALL-C AND THE FUTURE JLAB PHYSICS PROGRAM.

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We discuss the preliminary results of the Resonant Spin Structure experiment and outline a future spin-dependent measurement in JLab's experimental Hall C.

1. Resonant Spin Structure

The Resonant Spin Structure (RSS) collaboration[a] has performed an inclusive measurement of the spin asymmetries of the proton and deuteron in the resonance region, using a longitudinally polarized 5.7-GeV electron beam and a polarized solid ammonia target in JLab's Hall C. The target could be polarized longitudinally and transversely, allowing extraction of both spin-dependent structure functions g_1 and g_2 at $\langle Q^2 \rangle \approx 1.3$ GeV^2. This data will provide a test of polarized duality and allow an examination of higher twist effects. We mainly discuss the proton data analysis[1] below.

1.1. *Experiment*

In RSS experiment which ran in Jefferson Lab's Hall C, a 100 nA beam of longitudinally polarized 5.7-GeV electrons was incident on the University-of-Virginia (UVa) polarized NH_3 (or ND_3) target[2]. The High Momentum Spectrometer (HMS) was stationed at an angle, $\theta = 13.15°$, to inclusively measure scattered electrons. The HMS was outfitted with a series of scintillator planes and drift chambers for tracking and to provide the data acquisition trigger. A gas Čerenkov and lead glass calorimeter were used for particle identification. Two spectrometer momentum settings of 4.7 and 4.1 GeV allowed us to cover the resonance region up to an invariant mass W

[a] JLab E01-006, O. A. Rondon-Aramayo and M. Jones spokespersons.

of approximately 1.9 GeV. The basic measured quantity was a beam-target asymmetry defined as $A = A_{raw}/(fP_bP_tC_Nf_{RC}) + A_{RC}$ for the proton target where P_b and P_t represent the beam and target polarization, f is the dilution factor, which arises from the presence of unpolarized material in the target, and A_{raw} is the raw counts asymmetry measured when the beam helicity was flipped at 30 Hz while the target polarization was held fixed. C_N is a correction for the small residual polarization of Nitrogen in NH_3, and f_{RC} and A_{RC} represent radiative corrections, which account for the radiation of photons by the incoming and scattered electrons.

From $A_{\parallel}$ and $A_{\perp}$, the virtual photon asymmetries are calculated as:

$$A_1 = \frac{C}{D}\Big(A_{\parallel} - dA_{\perp}\Big) \qquad A_2 = \frac{C}{D}\Big(c'A_{\parallel} + d'A_{\perp}\Big), \tag{1}$$

where $C = 1/(1+\eta c')$; $\eta = \varepsilon\sqrt{Q^2}/(E-\varepsilon E')$; $\epsilon^{-1} = 1+2(1+\gamma^{-2})\tan^2(\frac{\theta}{2})$; $c' = \eta(1+\varepsilon)/(2\varepsilon)$; $\gamma = Q/\nu$; $D = (1-\varepsilon E'/E)/(1+\varepsilon R)$ is the virtual photon depolarization factor; $R = \sigma_L/\sigma_T$; $d' = 1/\sqrt{2\varepsilon/(1+\varepsilon)}$; and $d = \eta d'$.

Finally, the spin-dependent structure functions are given by:

$$g_1 = \frac{F_1}{1+\gamma^2}\left[A_1 + \gamma A_2\right] \qquad g_2 = \frac{-F_1}{1+\gamma^2}\left[A_1 - A_2/\gamma\right], \tag{2}$$

Recent fits[3] to Hall C inclusive inelastic $e-p$ data were used as input for F_1 and R.

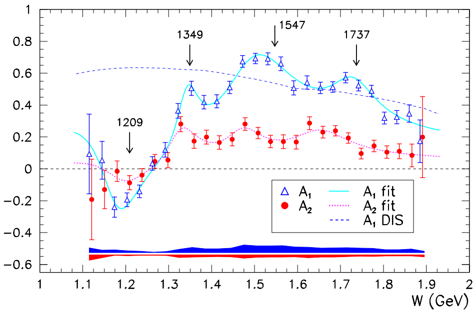

Figure 1. Preliminary results of Virtual Photon Asymmetries A_1^p and A_2^p versus W.

1.2. *Results*

Figure 1 shows the virtual photon asymmetries A_1^p and A_2^p versus W. The fits to our data[1] are also shown along with the E155 fit to DIS data evalu-

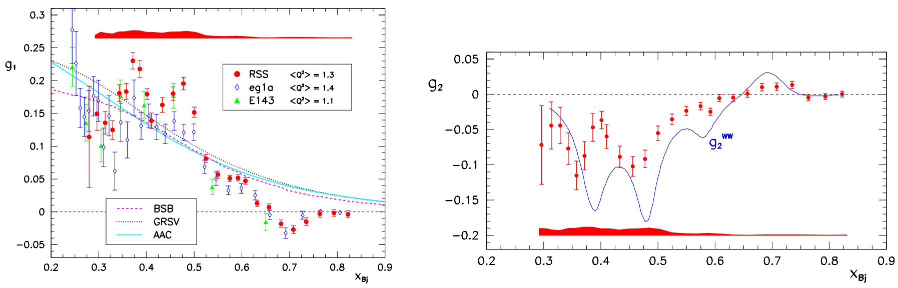

Figure 2. Preliminary results of proton g_1 and g_2 structure functions versus x_{bj}.

ated at our (x, Q^2). We observe four resonances in our region of W. The arrows mark the resonances as found by our fit to A_1^p.

Figure 2 shows the proton structure functions g_1 (left plot) and g_2 (right plot) versus Bjorken scaling variable x_{bj}. Also shown in the left plot are the previous measurements[5,6] as well as DIS extrapolations calculated from target-mass-corrected[7], next-to-leading-order parton distribution functions (PDFs)[8] over the same range of W and our average Q^2. To perform a test of local duality, the integral of g_1 was obtained using our fit over the four resonance regions and was compared to the integral from the same W region for each of the PDFs. Table 1 gives the integral ratios *averaged* over the three PDFs. The errors quoted are statistical uncertainty (2nd column) and the phenomenology model systematics for the PDFs (3rd column). If those errors are simply added to obtain the total uncertainty, the global ratio becomes consistent with 1.0 to less than 2σ. However, the ratios obtained from the individual resonances deviates from 1.0 by 2σ or more. Therefore, local duality is not observed in g_1^p at $Q^2 \sim 1.3$ GeV^2.

In the right plot of Figure 2, the leading twist g_2^{WW}[9] calculated from our g_1 fit at $Q^2 = 1.3$ GeV^2 is also shown. There is a clear evidence of higher twist contribution to g_2, which is given by the difference between g_2 and g_2^{WW}, over a wide range of x_{bj}. We also evaluated the twist-3

Table 1. Preliminary results of local and global duality

Resonance	W range (GeV)	Ratio (PDF to data fit)
Delta	1.12 – 1.30	4.80 ± 0.68 ± 0.37
R1	1.30 – 1.40	1.34 ± 0.07 ± 0.07
R2	1.40 – 1.69	0.78 ± 0.04 ± 0.04
R3	1.69 – 1.81	0.84 ± 0.04 ± 0.04
Global	1.08 – 1.91	1.17 ± 0.06 ± 0.06

matrix element, $d_2 = \int_0^1 x^2(2g_1 + 3g_2)\,dx$. The measured value of $\overline{d_2}$ for $0.29 < x < 0.84$ at $Q^2 = 1.3$ GeV^2 is more than 3σ above zero[1] while the previous measurement[10] (Lattice QCD calculation[11]) at $Q^2 = 5.0$ GeV^2 is consistent with zero within 2σ (1σ).

The results from the deuteron data are very preliminary. We will extract the neutron spin structure functions from the deuteron and proton data.

2. Future Experiment at JLab

The Spin Asymmetries on the Nucleon Experiment[b] (SANE), which will run in 2008 at JLab, aims to study the x and Q^2 dependence of the proton spin structure function $g_2(x, Q^2)$ and spin asymmetry $A_1^p(x, Q^2)$ for $2.5 < Q^2 < 6.5$ GeV^2 and for $0.3 < x < 0.8$. This will allow an examination of twist-3 effects and a test of polarized duality for $W > 1.4$ GeV. The longitudinally polarized electron beam and UVa polarized NH_3 target will be utilized, along with the novel non-magnetic βeta (Big Electron Telescope Array) detector which consists of a front hodoscope, a gas Čerenkov, a lucite hodoscope, and a large acceptance (194 msr) lead glass calorimeter (BigCal, built for the upcoming high Q^2 measurement of the proton elastic form factor ratio[12]). From the precise measurement of g_1^p and g_2^p in SANE, the d_2 matrix element will be extracted at $Q^2 = 3.5$ and 5.5 GeV^2 with uncertainty better than the previous measurements.

References

1. F.R. Wesselmann *et al.*, to be submitted to Phys. Rev. Lett.
2. D. G. Crabb and W. Meyer, Ann. Rev. Nucl. Part. Sci., **47** (1997) 67.
3. M.E. Christy *et al.*, to be published.
4. P. L. Anthony *et al.* [E155], Phys. Lett. B **493**, (2000) 19; F.R. Wesselmann, Ph.D. thesis, Old Dominion University (2000), SLAC-R-557.
5. K. Abe *et al.* [E143], Phys. Rev. D **58**, (1998) 112003.
6. R. Fatemi *et al.* [CLAS], Phys. Rev. Lett. **91**, (2003) 222002
7. J. Blumlein and A. Tkabladze Nucl. Phys. **B553**, (1999) 427
8. M. Hirai *et al.*, Phys. Rev. D **69** (2004) 054021; M. Glueck, E. Reya, M. Stratmann and W. Vogelsang, Phys. Rev. D **53** (1996) 4775; C. R. V. Bourrely, J. Soffer, and F. Buccella, Eur. Phys. J. C **41**, (2005) 327.
9. S. Wandzura and F. Wilczek, Phys. Lett. B **72**, (1977) 195.
10. P. L. Anthony *et al.* [E155], Phys. Lett. B **553**, (2003) 18.
11. M. Göckeler *et al.*, Phys. Rev. D **72**, 054507 (2005)
12. C.F. Perdrisat *et al.*, Jefferson Lab Proposal E-04-108

[b]JLab E03-109, O. A. Rondon-Aramayo, Z.-E. Meziani, S. Choi spokespersons.