2013-2014 JLab/JSA Graduate Fellowship Progress Report
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1 Introduction

This document will summarize the progress made during my JSA Fellowship year. I worked primarily on the data analysis of my thesis experiment, “A Measurement of $g_2^p$ and the Longitudinally-Transverse Spin Polarizability” (E08-027), which ran in Hall A at Jefferson Lab during the spring of 2012. This data will provide the first measurement of the polarized spin structure function $g_2$ for the proton in the resonance region, $0.02 < Q^2 < 0.2$ GeV$^2$. The $0^{th}$ moment of $g_2$ provides a test for the Burkhardt-Cottingham sum rule, which says that the integral of $g_2$ over the Bjorken scaling variable $x$ goes to zero. This sum rule, valid for all values of $Q^2$, has been satisfied for the neutron, but a violation is suggested for the proton at high $Q^2$. In addition, the $2^{nd}$ moment of $g_2$ allows for a test of $\chi$PT at low $Q^2$. Specifically, the behavior of the longitudinally-transverse spin polarizability, $\delta_{LT}$, as $\chi$PT calculations of this quantity deviate significantly from the measured neutron data. Finally, this data will provide crucial input to the study of the hyperfine splitting of hydrogen and the proton charge radius.

2 Research

Data analysis for the $g_2^p$ experiment is currently pushing forward. During my fellowship year, I worked on extracting the packing fraction values for the ammonia targets used during the experiment. A picture of the target stick is shown in figure 1. The proton target used in this experiment was comprised of frozen ammonia (NH$_3$ beads), packed into a cylindrical cell. The target cell was submerged in liquid helium at 1K during the course of the experiment. The packing fraction, $p_f$, represents the fraction of the cell that is filled with ammonia, and is important for understanding the percentage of events which scatter from unpolarized material. While ideally the cell would be completely full ($p_f = 1$), variation in the size of the NH$_3$ beads and varying load sizes of the material samples result in a different $p_f$ value for each material. There were 10 different NH$_3$ samples used throughout the course of the experiment.

![Figure 1](image.png)

Figure 1: Target stick used for the $g_2^p$ experiment. The different targets are, from left to right, a carbon foil, an empty target cell, and two cells filled with ammonia. The stick is submerged in liquid helium throughout the run.
To extract the packing fraction, data taken at the elastic setting was used, as it allows for good separation between the nitrogen and hydrogen elastic peaks. Additional runs were taken on an identical target cell, filled only with liquid helium, to help understand the contribution from the liquid helium in the target cell. As part of this project, I wrote code to extract the normalized yields from the data. Additionally, I developed a fitting routine to fit the resulting spectra, using input from QFS model simulations to understand the relative contributions from the different materials within the target cell. During this time I also developed software to extract preliminary asymmetry results. The $g_2^p$ results are extracted by combining the asymmetry and absolute cross section results; we hope to have preliminary results for $g_2$ in the next 6-12 months. Preliminary asymmetry and yield results can be seen in figure 2.

Figure 2: Preliminary results for the $g_2^p$ experiment. On the left are asymmetry results (normalized by beam and target polarizations) and on the right are yield results.

3 Travel

The travel grant from this fellowship allowed me to attend the 22nd International Workshop on Deep Inelastic Scattering (DIS2014) in Warsaw, Poland. I gave a talk titled The $g_2$ Spin Structure Function. The proceedings from this conference can be found at [1]. I would like to thank the JSA/SURA for providing me with this opportunity.

References