PRELIMINARY RESULTS OF $^{2}\vec{H}\,(\vec{e}, e'p)\,n$ IN BLAST

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Due to its simple composition, the deuteron has long been recognized as important in understanding the structure of the inter-nucleon potential. With this goal, a comprehensive study of low-Q^2 spin-dependent electron scattering from deuterium is currently underway using the polarized electron beam provided by the MIT-Bates linear accelerator. Using the BLAST (Bates Large Acceptance Spectrometer Toroid) detector together with an internal vector/tensor polarized deuterium target, a comprehensive spin-dependent analysis of proton scattering is being performed. Due to the detector's large acceptance and symmetric design, simultaneous determination of the deuteron's parallel and perpendicular asymmetries is possible over a Q^2 range between 0.1 and 0.5 GeV^2. Preliminary asymmetry results are presented here along with a comparison with theory.

1. Introduction

The deuteron, being the only bound two-nucleon system and thus the simplest one in which the nuclear force is manifest, is a natural starting point for an investigation of the nuclear electromagnetic current. Additionally, due to the lack of free neutron targets, deuterium has often been used as a good approximation to a free neutron target, thus enabling the extraction of neutron-related physics measurables, such as G_E^n[1,2]. However, in order to model deuterium as a free neutron target, one must be able to account for effects due to the neutron being bound within the deuterium nucleus. Accounting for such effects requires an accurate knowledge of the deuteron spin structure as well as the inter-nucleon potential along with reaction mechanisms, such as meson-exchange currents (MEC), isobar configurations (IC), and relativistic corrections (RC). For these reasons, comprehensive measurements of deuteron observables are essential.

Measurements of spin-dependent deuteron observables have the potential to enhance our understanding of nucleon and nuclear structure by providing access to small but dynamically-interesting amplitudes which otherwise disappear or get washed out in spin-independent processes[3]. In particular, coincidence ${}^2\vec{H}(\vec{e},e'p)n$ reactions show much promise towards advancing our understanding of the inter-nucleon interaction.

The cross section for exclusive deuteron electrodisintegration can be written as follows[4]:

$$S\left(h,P_z,P_{zz}\right)=S\left(0,0,0\right)\Big\{1+\sqrt{\tfrac{3}{2}}P_zA_d^V+\sqrt{\tfrac{1}{2}}P_{zz}A_d^T \\ +h\left(A_e+\sqrt{\tfrac{3}{2}}P_zA_{ed}^V+\sqrt{\tfrac{1}{2}}P_{zz}A_{ed}^T\right)\Big\} \quad (1)$$

where h is the electron beam polarization and P_z and P_{zz} are the respective deuterium target vector and tensor polarizations. The $A_{(d,e,ed)}^{(V,T)}$ terms are the various beam/target asymmetries, and $S\left(0,0,0\right)$ is the totally-unpolarized cross section. When one considers a pure S-wave deuteron, the tensor asymmetry (A_d^T) vanishes. Thus, measurements of A_d^T can provide insight into the tensor component of the internucleon potential. In addition, the beam-vector asymmetry (A_{ed}^V) when the proton is detected exhibits sensitivity to various reaction mechanisms.

2. The BLAST Spectrometer and Experimental Setup

This measurement is being performed at the MIT-Bates Linear Accelerator Center using the BLAST (Bates Large-Acceptance Spectrometer Toroid) detector. A longitudinally polarized 0.850 GeV electron beam is incident on an internal atomic beam source (ABS) polarized deuterium target. The deuterium target sequentially switches between three polarization states, $(P_z,P_{zz})=(p_z,p_{zz})$, $(-p_z,p_{zz})$, and $(0,-2p_{zz})$. The beam polarization is measured via a compton polarimeter; the target's vector and tensor polarizations are determined via fits of the data to Monte Carlo results. By flipping the beam's helicity as well as the target's polarization states, it is possible to measure all five of the asymmetries listed in Eq. 1.

Scattered particles are detected in the BLAST detector (see Fig. 1). The detector is based around an eight sector toroidal magnet with two opposing sectors instrumented with left/right symmetric detectors. Each detector sector is equipped with three drift chambers (for momentum reconstruction) as well as a layer of Cerenkov counters (for electron/pion discrimination), a layer of scintillators (for time-of-flight measurements), and a layer of neutron counters. In addition, the right sector is instrumented with an additional three layers of neutron counters. The drift chambers have a large acceptance, allowing measurements to be made over a Q^2 range of 0.1 to 0.5 GeV^2.

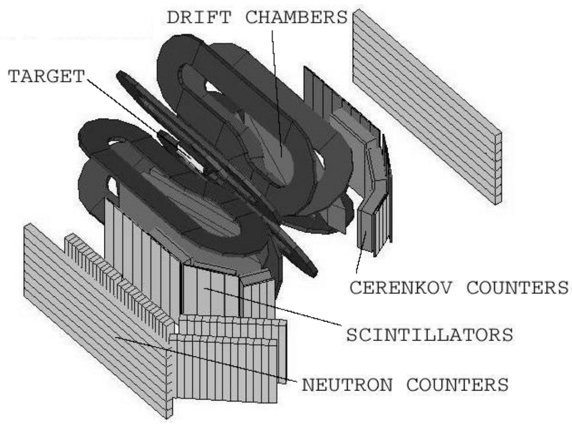

Figure 1. The BLAST spectrometer

The target's polarization vector is aligned in-plane within the left sector so as to form a 32° angle with the beam line. By doing so, it is possible to isolate various parallel/perpendicular asymmetry components. For example, an electron passing through the left (right) sector has a corresponding three-momentum transfer vector, $\vec{q}$, that lies within the right (left) sector, and thus $\vec{q}$ is approximately perpendicular (parallel) to the target polarization vector, $\vec{s}_d$. Thus, electrons detected in the left (right) sector will emphasize asymmetry components that go as the cosine (sine) of the angle between $\vec{q}$ and $\vec{s}_d$.

3. Preliminary Results

Figs. 2 and 3 show our asymmetry results as compared to a theoretical model from H. Arenhovel et. al.[4] Systematic errors, though expected to be small, have not yet been incorporated into the analysis; all error bars in the figures are purely statistical.

The reconstructed tensor asymmetries show the same high missing-momentum "hump" as the theoretical ones, supporting the existence of a tensor component of the inter-nucleon potential. The reconstructed beam-vector asymmetries show the expected rise at high missing-momentum and lend evidence towards the necessity for the inclusion of reaction mecha-

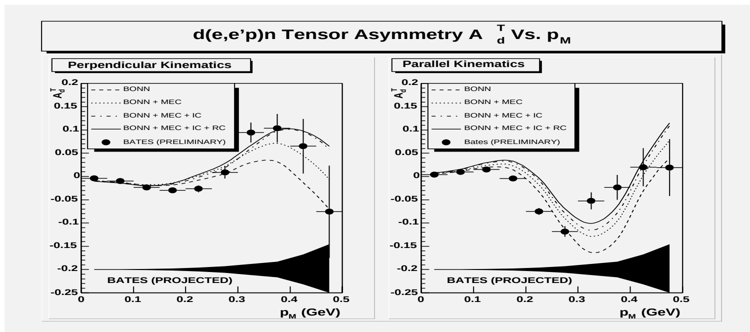

Figure 2. $^2\vec{H}(\vec{e},e'p)n$ Tensor Asymmetry, A_d^T, versus missing-momentum, p_M

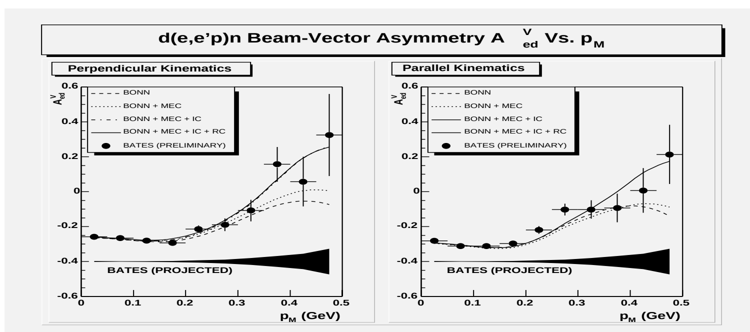

Figure 3. $^2\vec{H}(\vec{e},e'p)n$ Beam-Vector Asymmetry, A_{ed}^V, versus missing-momentum, p_M

nism effects. The results presented here are for roughly half of the total $^2\vec{H}\,(\vec{e},e'p)\,n$ data expected to be collected. The projected errors for the full amount of data show that our results should go far to help discriminate between various reaction mechanism contributions.

References

1. B. R. Plaster, Ph.D. thesis, Massachusetts Institute of Technology, 2004 (unpublished)
2. R. Madey, et. al., *Phys. Rev. Lett.*, **91**, 122002 (2003)
3. BLAST proposed-approved experiment 00-03, "A Study of the Deuteron Structure Using Tensor Polarized Deuterium and the BLAST Detector", spokesperson: Z. Zhou, 2000, p.3
4. H. Arenhovel, W. Leidemann, and E. L. Tomusiak, *Phys. Rev. C*, **46**, 455 (1992)