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Research Statement

My primary research interest lies in the use of accelerated polarized particle beams to study fundamental symmetries and the effects of symmetry breaking at hadronic energy scales. Currently, my main focus is on parity-violating electron scattering, in particular the Q_{Weak} experiment at the Thomas Jefferson National Accelerator Facility or Jefferson Lab. I am also involved in future experiments, such as the proposed Møller and SoLID experiments at Jefferson Lab, and in the design of experiments at a future electron-ion collider (EIC).

In my dissertation research I investigated exotic baryon decays in the data collected at the polarized electron-beam fixed-target experiment HERMES in Hamburg, Germany. Exotic baryons are states consisting of a minimum of five quarks, instead of the three quarks in regular baryons. Initial claims of the existence of these so-called pentaquark states could not be unambiguously confirmed by the HERMES experiment [1]. Additional data was collected but the analysis lead to a somewhat unsatisfactory conclusion because of the distorting effect from the polarized target holding fields. Recent progress based on my work on the reconstruction of displaced vertices in these magnetic fields has resulted in an improved tracking resolution which will allow for reduced ambiguity.

My experience in spectroscopy at the HERMES experiment enabled me to contribute significantly to an highly rated proposal for the A2 experiment in Mainz, Germany. We aim to measure neutral pion photoproduction at threshold using circularly polarized real photons on a transversely polarized hydrogen target with the Crystal Ball and TAPS detectors [2]. The experiment will allow us to determine the region of convergence of chiral perturbation theory and to test strong isospin breaking effect. The beam time for this experiment has not been scheduled yet but we anticipate to run in 2010. The analysis of threshold photoproduction data collected previously on an unpolarized hydrogen target is currently in progress.

The $\mathbf{Q_{Weak}}$ Experiment: A Search for New Physics at the TeV Scale

The Q_{Weak} experiment [3] is scheduled to run from May 2010 until May 2012 in experimental Hall C at Jefferson Lab. By measuring the parity-violating cross section asymmetry between the elastic scattering of positive and negative helicity electrons on the protons in a liquid hydrogen target, the experiment aims to determine the weak charge of the proton, $Q^p_{Weak} = 1 - 4\sin^2\theta_W$, to a precision of 4%. Just as the regular electric charge of fermions is given by their coupling to photons, the coupling to Z bosons determines their weak charge. The influence of heavy, as of yet unknown particles can become visible in precision measurements of Q^p_{Weak}. The deduced value of $\sin^2\theta_W$ will be the most accurate to date at low energies, as can be seen on figure 1.

The measured parity-violating asymmetry is proportional to the squared momentum trans-

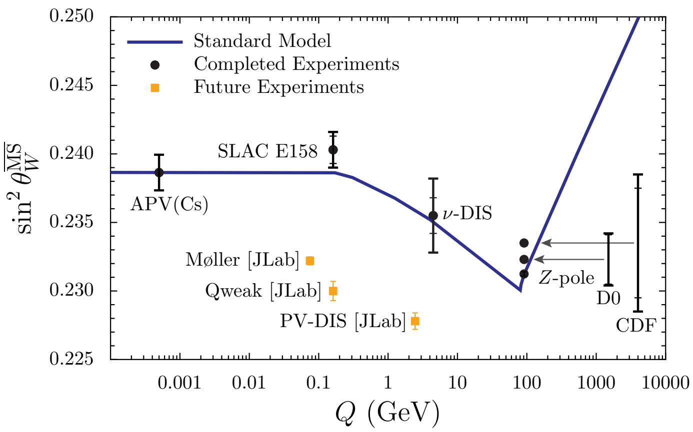

Figure 1: The running of the weak mixing angle $\sin^2\theta_W$ as predicted in the Standard Model is indicated by the curve, with the available experimental data points shown in black. The abscissa and projected uncertainties for the Q_{Weak}, MOLLER, and SoLID (PV-DIS) experiments are indicated in red. Figure by Bentz, Cloet, Londergan, Thomas; arXiv:0908.3198 [nucl-th].

fer Q^2. The soft hadronic contributions to the asymmetry have to be corrected for, and are proportional to Q^4. The determination of the momentum transfer is therefore one of the largest systematic uncertainties of the Q_{Weak} experiment. A dedicated tracking system, consisting of GEM detectors and drift chambers on either sides of a toriodal magnet, will allow us to measure the momentum of the scattered electrons. I am coordinating the efforts of the tracking software group from stub finding to the determination of the momentum.

The dominant experimental systematic uncertainty in the Q_{Weak} experiment will be the knowledge of the electron beam polarization, which enters linearly in the measured asymmetry. With a new Compton polarimeter [4] we aim to measure the beam polarization to a statistical precision of 1% in one hour and a systematic uncertainty of 1%. The asymmetry in the cross section for aligned and anti-aligned electron and photon spins allows us to determine the electron beam polarization from the measured scattered electrons and photons. The main components of this new Compton polarimeter are a low-gain high-power cavity laser system, a radiation-hard diamond strip electron detector, and a fast photon detector. I am responsible for the construction of the photon detector, implemented as a pure CsI scintillator detector, and in the integration, data acquisition and data analysis of the Compton polarimeter. These skills will be valuable for polarimetry in the future parity-violating electron scattering experiments discussed next.

Parity-Violating Electron Scattering after the 12 GeV Upgrade

After the Q_{Weak} experiment, the CEBAF accelerator at Jefferson Lab will be upgraded to provide an 11 GeV electron beam to the three existing halls A, B and C, and a fourth hall D will be constructed for experiments with bremsstrahlung photons from the 12 GeV electron beam. Two large-installation parity-violation experiments for Hall A have already been proposed: the Moller experiment aims to measure parity-violating effects in electron-electron Møller scattering at very forward angles [5], and the SoLID experiment will investigate the parity violation in deep-inelastic scattering on various target using a solenoidal spectrometer [6]. The projected results of both these experiments are indicated in figure 1. Currently, I am contributing to the Monte Carlo simulations for the Moller experiment. I intend to take a leading role in the precision electron polarimetry for these experiments. In particular, if an atomic hydrogen trap polarimeter proves feasible, I would like to pursue its design and construction in collaboration with groups at the University of Michigan and the University of Virginia.

Electroweak Physics at the Electron-Ion Collider

The importance of a new electron-ion collider facility was underscored by the recommendations in the most recent NSAC long-range plan. Two separate conceptual designs are being pursued in the US: the extension of the RHIC facility at Brookhaven National Lab with a linear recirculating electron accelerator, and the addition of a hadron collider ring complex at Jefferson Lab. The kinematic parameters of these designs are close to those of the Hermes experiment, thus providing me with valuable experience. In both designs there would be a possiblity to include experiments based on parity-violating scattering, although no concrete proposals have been worked out yet. The electron beam polarization requirements for the experiments at the EIC are similar to those after the 12 GeV upgrade. In 2007, I preformed a study of a possible electron polarimeter layout, and I have been asked to take a coordinating role in the planning of the electron polarimetry for the EIC. I will contribute to the electroweak program at EIC as experimental designs continue to form.

References

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