Dissertations

Probing Novel Properties of Nucleons and Nuclei via Parity Violating Electron Scattering

Luis Rafael Mercado, *University of Massachusetts - Amherst*

Date of Award
5-2012

Document Type
Open Access Dissertation

Degree Name
Doctor of Philosophy (PhD)

Degree Program
Physics

First Advisor
Krishna Kumar

Second Advisor
Lorenzo Sorbo

Third Advisor
David Kawall

Keywords
asymmetry, happex, parity, prex, quarks, strange

Subject Categories
Physics

Abstract
This thesis reports on two experiments conducted by the HAPPEx (Hall A Proton Parity Experiment) collaboration at the Thomas Jefferson National Accelerator Facility. For both, the weak neutral current interaction (WNC, mediated by the Z0 boson) is used to probe novel properties of hadronic targets. The WNC interaction amplitude is extracted by measuring the parity-violating asymmetry in the elastic scattering of longitudinally polarized electrons off unpolarized target hadrons. HAPPEx-III, conducted in the Fall of 2009, used a liquid hydrogen target at a momentum transfer

of Q^2 = 0.62 GeV^2. The measured asymmetry was used to set new constraints on the contribution of strange quark form factors ($G^s_{E,M}$ to the nucleon electromagnetic form factors. A value of A_{PV} = -23.803 +- 0.778 (stat) +- 0.359 (syst) ppm resulted in G_E^s + 0.517 G_M^s = 0.003 +- 0.010 (stat) +- 0.004 (syst) +- 0.009 (FF).

PREx, conducted in the Spring of 2010, used a polarized electron beam on a ^{208}Pb target at a momentum transfer of Q^2 = 0.009 GeV^2. This parity-violating asymmetry can be used to obtain a clean measurement of the root-mean-square radius of the neutrons in the ^{208}Pb nucleus. The Z0 boson couples mainly to neutrons; the neutron weak charge is much larger than that of the proton. The value of this asymmetry is at the sub-ppm level and has a projected experimental fractional precision of 3%.

We will describe the accelerator setup used to set controls on helicity-correlated beam asymmetries and the analysis methods for finding the raw asymmetry for HAPPEx-III. We will also discuss in some detail the preparations to meet the experimental challenges associated with measuring such a small asymmetry with the degree of precision required for PREx.