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BSc (Physics and Mathematics), Saint Mary's University, 2013

DEPARTMENT OF PHYSICS AND ATMOSPHERIC SCIENCE

TITLE OF THESIS: MEASUREMENT OF THE ELASTIC FORM FACTOR RATIO μGE/GM USING ELECTRON SCATTERING SPIN ASYMMETRIES

TIME/DATE: 2:00 pm, Friday, July 13, 2018

PLACE: Room 3107, The Mona Campbell Building, 1459 LeMarchant Street

EXAMINING COMMITTEE:

Dr. Robert Pywell, Department of Physics, University of Saskatchewan (External Examiner)

Dr. Andrew Rutenberg, Department of Physics and Atmospheric Science, Dalhousie University (Reader)

Dr. David Hornidge, Department of Physics and Atmospheric Science, Dalhousie University (Reader)

Dr. Rituparna Kanungo, Department of Physics and Atmospheric Science, Dalhousie University (Reader)

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CHAIR: Dr. Djordje Grujic, PhD Defence Panel, Faculty of Graduate Studies

ABSTRACT

Electron scattering is a powerful tool for studying the internal structure of the proton. In particular, elastic electron-proton scattering is used to access the electromagnetic form factors (G_E and G_M) due to an implied connection between the spatial distribution of the proton's charge and magnetism to the form factors' dependence on the scattering momentum transfer (Q^2). This focus was spurred by experimental developments of polarization parameters in scattering to access the elastic form factor ratio (FFR) $\mu G_E / G_M$. There is a renewed interest in the low Q^2 region where the FFR can only be described by QCD-inspired models and phenomenological fits that are sensitive to the long-range structure of the proton. This is important because the form factors' Q^2 slope, as Q^2 tends to zero, defines the proton's radius.

This thesis reports on a novel method to analyze and extract the proton elastic FFR at the lowest Q^2 range ever attempted ($0.01 \leq Q^2 \leq 0.08$ GeV^2) from an experiment conducted in 2012 at Jefferson Lab (E08-007). The experiment used a polarized electron beam, a polarized proton target, and two high-resolution spectrometers (HRS) to detect scattered electrons at ≈6° on either side of the beam (left, right) for independent measurements. A previous independent analysis had been conducted on the left HRS data, but experimental difficulties prevented that analysis from extracting the FFR, but provided polarization asymmetries for the left HRS.

The analysis method used did not rely on the standard use of the magnetic optical transformation matrix. The analysis utilized the measured momentum distributions from the scattering reactions. A Monte Carlo simulation of the experiment was used to model and fit the observed momentum distributions to extract the FFR. While this method did not yield a reliable FFR result for the right HRS, it was able to confirm the left HRS asymmetry found in the previous analysis and extracted one value at $Q^2 = 0.0513$ GeV^2 for $\mu G_E / G_M = 1.147 \pm 0.017$. This result indicates an upward trend in the ratio as Q^2 approaches zero, since it is significantly higher than existing data at low Q^2. Given the connection of the low Q^2 form factor slope to the proton size, the result of this thesis points to a need for follow-up measurements.