CEBAF Experiment 01-001

New Measurement of (G_E/G_M) for the Proton.

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The structure of the proton is a matter of universal interest in nuclear and particle physics. Charge and current distributions are obtained through measurements of the electric and magnetic form factors, $G_E(Q^2)$ and $G_M(Q^2)$. These form factors can be determined by performing a Rosenbluth separation. Several such experiments have been performed, and global fits to these measurements found form factors consistent with the dipole form and a ratio of G_E to G_M consistent with unity (*i.e.* scaling of the form factors). However, while no experiment was inconsistent with scaling, the results show a significant scatter.

Recent experiments in Hall A at Jefferson Laboratory used a polarization transfer method to extract G_E/G_M up to $Q^2 = 5.6$ GeV^2. They found that the ratio of G_E/G_M is unity at low Q^2, but falls with increasing Q^2, reaching a value of 0.6 at $Q^2 = 3$ GeV^2. While this new technique is less prone to systematic uncertainties than the Rosenbluth separation, the discrepancy between the two techniques must be resolved before results from either technique can be fully accepted.

Experiment E01-001 will measure G_E/G_M at Q^2=1.4, 3.2, and 4.9 GeV^2 using a modified Rosenbluth separation technique that will substantially reduce the uncertainty compared to previous measurements. To measure at two different values of ϵ, data must be taken at different beam energies and different electron scattering angles. Imperfect knowledge of the accumulated beam charge, target density, and scattering kinematics are some of the most significant sources of uncertainty in the previous measurements. To reduce the dependence on beam charge and target density, we will make simultaneous measurements at the desired (high) Q^2 value and at a low Q^2 normalization point (0.5 GeV^2). Because the value of G_E/G_M at low Q^2 is relatively well known, and because the kinematics chosen make this point insensitive to the virtual photon polarization, normalizing to the low Q^2 point eliminates the need to accurately know the beam charge and target thickness. The other major difference in this experiment is that we will detect the struck proton rather than the scattered electron. This significantly reduces the sensitivity to the scattering angle at high ϵ (corresponding to small electron scattering angles and large proton angles) where it is a significant contribution to the uncertainty. It also increases the cross section at low ϵ (backwards angle electrons and forwards angle protons), where the cross section becomes a limiting factor in the electron measurement. Detecting the proton also has the advantage that the radiative corrections are both smaller than in the electron case and less dependent on ϵ. Finally, because the proton momentum is fixed for a given Q^2, the detected particle is at the same momentum for both the forward and backward angle measurements, reducing the uncertainty from any momentum-dependent corrections to the cross section.

The uncertainty in the extraction of the ratio depends on the value of G_E/G_M. Assuming form factor scaling (G_E/G_M=1 at all Q^2), the uncertainty on the ratio is 2.1% at Q^2=1.4 GeV^2, 4.2% at 3.2 GeV^2, and 9.7% at 4.9 GeV^2. At each Q^2 point, this experiment will differentiate between form factor scaling and the Hall A results for G_E/G_M at the 5 σ level or better, and thus will definitively determine if the Rosenbluth technique and the Hall A polarization transfer method give consistent results.